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FORAMINIFERA FROM THE WALNUT FORMATION (LOWER CRETACEOUS) OF NORTHERN TEXAS AND SOUTHERN OKLAHOMA[1]

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ABSTRACT—The foraminiferal fauna of the Walnut clay (Fredericksburg group) in northern Texas and southern Oklahoma is described, with a total of 47 species, including 13 new. Thirty-three genera, of which two are new, and 12 families are represented. The family Lituolidae contains the greatest number of the species and the Lagenidae are next in number.

INTRODUCTION

THE present study is the first of a series describing Lower Cretaceous Fredericksburgian (Albian) Foraminifera from the outcrop in North Texas and Southern Oklahoma. Little is known at present of the foraminiferal faunules, ranges, facies control or occurrence within the limits of the Fredericksburgian. In the material here presented consideration is given only to the marginal sandy clay facies of the Walnut at its northern area of outcrop. The foraminiferal fauna is thus limited in scope, only 47 species being recorded. To the south in the more marly facies the faunules are richer in variety.

The marginal Walnut beds here considered have been variously interpreted during the past as being Trinity or Fredericksburg in age. Hill originally defined the Walnut clays in central Texas (1891, p. 512) and considered (1901, p. 207) that "from Wise County [Texas] northward the Walnut formation rests upon and passes horizontally into the Basement (Antlers) sands, the upper part of which is no doubt the equivalent of the Walnut formation of the more southern sections." He (1901, p. 208) stated that ". . . a few miles northwest of Marietta, Indian Territory [Oklahoma] the Walnut formation is represented by a few clay layers bearing *Exogyra texana* in the Basement sands beneath the Goodland limestone."

Stephenson (1919, p. 130) considered the northern equivalent of the Walnut to be the basal three to six feet of the Goodland limestone consisting of hard persistent coquina-like limestones with interbedded layers of dark marly shale and termed them the Walnut Shaly member. This horizon immediately overlies the *Exogyra texana* beds mentioned by Hill.

Bybee and Bullard (1927, p. 15) did not consider the Walnut clay to be the lower bed of the Goodland as did Stephenson but

[1] Published by permission of the Secretary of the Smithsonian Institution.
[2] Arrangement of names alphabetical, no seniority implied.
[3] Mrs. Alfred R. Loeblich, Jr.

stated that the "equivalent of the Walnut clay is another horizon still lower in the section." They recognized no distinct Walnut as such in the area of the Red River, but inferred the Walnut to be a four foot bed within the Trinity sand nearly 20 feet below the base of the Goodland.

Vanderpool (1933, p. 406) described some microfossils from the Marietta locality assigning these beds to the Trinity although stating (p. 407) "that the sub-Goodland sandy shale beds represent the upper part of the Paluxy formation deposited during latest Trinity or earliest Fredericksburg time."

Thompson (1935, p. 1516) presents a stratigraphic section on the Red River in northern Cooke County, Texas, the same as that given by Bybee and Bullard (1927, p. 12), but recognizes 19 feet of Walnut just below the Goodland consisting of 12 feet of non-calcareous shale and minor beds of shell agglomerates, arenaceous shale and sandy limestone, over a four foot shell agglomerate. Thompson (p. 1517) further stated that the upper non-calcareous shale of the Walnut is mappable into yellow clay marl farther south and that this northern non-calcareous shale is interpreted as a shoreward facies. At the Marietta locality the Walnut is considerably thinner than in northern Cooke County, being less than two feet in thickness.

Lozo (1944, p. 520) in a study of Trinity and Fredericksburg Foraminifera stated that three of the species recorded by Vanderpool (*Ammobaculites subgoodlandensis* Vanderpool, *Vaginulina intumescens* Reuss and "*Textularia conica*" = *T. rioensis* Carsey) have not been elsewhere observed below the Walnut formation and therefore "that the sub-Goodland yellowish sandy shales of this locality are Fredericksburg in age and represent the marginal, near shore facies of the Walnut formation to the south."

The writers agree with Hill, Lozo and Thompson in considering the "sub-Goodland" of southern Oklahoma and northern Texas to be the equivalent of the southern Walnut, and on the basis of the large number of species of Foraminifera common to this horizon and the Goodland, place it within the Fredericksburg division, rather than the Trinity as did Hill, Vanderpool, Bullard and Bybee.

LOCALITIES AND SAMPLES

Locality HTL-74.—In a high cliff on the east side of U. S. Highway 77, 3.4 miles by road north of the main road turning east to Marietta from the highway, in the SE¼, Sec. 31, T. 6 S., R. 2 E., Love County, Oklahoma. Section measured February 4, 1946 by W. E. Ham and A. R. Loeblich, Jr.

GOODLAND formation
4. limestone, heavy-bedded, massive ..... 8 feet
3. limestone, nodular and marly at the base grading upward into yellow stained limestone (transitional to typical Goodland lithology); Walnut shaly member of Stephenson ..... 2.2 feet

WALNUT formation
2. clay, gray, yellow, sandy. Sample 320. Paluxy of Vanderpool ..... 1.4 feet

ANTLERS formation
1. sandstone, very fine grained, buff, some red, loosely consolidated, with discontinuous seams of dove gray clay shale ..... about 30 feet

Locality HTL-105.—In a large square pit, excavated at the site of the Denison Dam, north of Denison, Grayson County, Texas. This pit was a short distance east of the main bluff formed during construction of the dam, the fauna of which was discussed by Lozo (1943), and is considerably lower stratigraphically. Section collected and measured by H. N. and A. R. Loeblich, Jr. in July 1940.

GOODLAND formation
6. limestone, massive, with thin undulating beds of clay (not measured)
5. limestone, nodular, separated by thin marls ..... 1 foot
4. shale, black, containing abundant *Gryphea* ..... 2–3 inches
3. limestone, gray, numerous shell fragments ..... 8 inches

WALNUT formation
2. shale, fissile, black. Sample 465 ..... 2 feet
1. shale, fissile, black, with sand stringers. Sample 464 ..... 2 feet

Base of Excavation (Note: Beds 3–5 represent the Walnut shaly member of Stephenson).

DEPOSITIONAL ENVIRONMENT

The marginal Walnut deposits would fall in Scott's (1940, p. 1167–1168) littoral or

epineritic zones indicating deposition in less than 20 fathoms. This is further substantiated by the occurrence of linguloid brachiopods in the Walnut at the Denison dam locality. *Lingula* is regarded as an excellent shore line indicator and unknown in modern waters deeper than 23 fathoms.

The only common megafossils are *Exogyra texana* Roemer and *Gryphea* sp., but washed samples produce a variety of fragmental mollusca, echinoid, holothurian and ophiuroid remains. Particles of lignite have been reported from the Walnut in northern Cooke County, Texas, and at the Denison dam locality carbonized wood was noted in some abundance by the writers. All samples observed were extremely sandy, washed residues being composed almost entirely of fine sand, fragmental fossil remains, Foraminifera and Ostracoda. Sediments on the outcrop vary in color from yellow-brown to black, but on fresh exposures observed such as at the Denison Dam pit the dominant color was black. Harris (in Vanderpool, 1933, p. 407) reported several genera of reworked Pennsylvanian fossils in the Walnut at the Marietta locality, but our sorting failed to verify this occurrence.

CHARACTER OF THE FORAMINIFERAL ASSEMBLAGES

Foraminiferal assemblages from the Walnut in north Texas and southern Oklahoma are dominated by the arenaceous Foraminifera, the family Lituolidae being the most abundant with 13 representatives. Several of these, such as *Buccicrenata* and *Lituola*, attain robust size and are the most abundant Foraminifera in the assemblages. The calcareous forms outnumber the arenaceous ones in species, but are represented by few individuals, the majority of the calcareous forms being quite rare.

ACKNOWLEDGMENTS

All samples used in this study were collected, washed and sorted and types were selected by the writers. The two localities were first visited by the writers in July, 1940, and samples were collected at that time. In February, 1946, A. R. Loeblich, Jr., and W. E. Ham of the Oklahoma Geological Survey revisited the Marietta locality, remeasured the section and collected additional material. The writers are indebted to Mr. Robert Dott, Director of the Oklahoma Geological Survey for making possible the association of Mr. Ham and for field expenses involved in a study of the Lower Cretaceous of southern Oklahoma.

TYPES

The figured types of the present paper, as well as a set of representative material, are deposited in the U. S. National Museum. The types of the paper by Vanderpool (1933) were originally deposited in the University of Oklahoma Micropaleontological Collections but in 1946 became the property of the U. S. National Museum. The two new species described by Vanderpool were each represented by more than one specimen, and there was no designation as to which specimen was the holotype, either in the paper itself or on the slide containing the types. Therefore, the writers have selected and designated a lectotype for each species from the original lot of Vanderpool. Unfigured paratypes and hypotypes are also deposited in the H. N. Loeblich Collection.

DESCRIPTION OF FORAMINIFERA

Family AMMODISCIDAE

Genus AMMODISCUS Reuss, 1861

AMMODISCUS ROTALARIUS Loeblich and Tappan, n. sp.

Plate 46, figure 1

Test free, discoid, consisting of a proloculum and long tubular undivided second chamber which increases in size regularly, periphery rounded, sides flat; spiral suture not depressed, somewhat obscure until specimens are dampened; wall finely arenaceous, with considerable cement; aperture at the open end of the tubular chamber.

Greatest diameter 0.30 mm., least diameter 0.28 mm., greatest thickness 0.08 mm.

Types and occurrence.—Holotype (USNM No. 104433) and paratypes (USNM No. 104434 and H. N. Loeblich Coll. No. 1094) from the Walnut clay at locality HTL-74, Love County, Oklahoma.

Remarks.—This species differs from *Ammodiscus gaultinus* Berthelin, which occurs in the Washita group, by its more regular coiling in a single plane and by the even amount of overlap.

Family LITUOLIDAE
Subfamily HAPLOPHRAGMIINAE
Genus TROCHAMMINOIDES Cushman, 1910
TROCHAMMINOIDES CORONUS
Loeblich and Tappan
Plate 46, figures 2 a, b

Trochamminoides coronus LOEBLICH and TAPPAN, 1946, Jour. Paleontology, vol. 20, no. 3, p. 243, pl. 35, figs. 3a–c.

Test free, small, discoidal, planispirally coiled, periphery rounded; chambers numerous and small, 12–14 in the last whorl, as many as three complete whorls may be seen; sutures straight, somewhat depressed, giving the periphery a lobulate appearance; wall finely arenaceous; aperture a low arch at the base of the apertural face of the final chamber, on the periphery.

Greatest diameter of hypotype 0.23 mm., greatest thickness 0.09 mm.

Types and occurrence.—Figured hypotype (USNM No. 104435), hypotype (H. N. Loeblich Coll. 1095), both from the Walnut clay at locality HTL-74, Love County, Oklahoma.

This species is also present in the 2.2 foot nodular and marly limestone of the Goodland, immediately overlying the Walnut clay at the above locality. We also have this species in the upper Goodland, in the low bluff on the east bank of the North Fork of Mary's Creek, at the concrete bridge on the Fort Worth-Weatherford Highway, 11¼ miles west of Fort Worth, Tarrant County, Texas. It was originally described from the Georgetown formation of the Washita group. It also occurs in the upper Fort Worth formation of the Washita group in a deep road cut on the west side of U. S. Highway 75 (Denison-Durant road), 1,000 feet north of the Calvary Cemetery, ½ mile north of the Texas Highway Department Information Station, 1.6 miles north of Main St., in Denison, Grayson County, Texas.

EXPLANATION OF PLATE 46

Ammodiscidae to Lituolidae

FIG. *1*—*Ammodiscus rotalarius* Loeblich and Tappan, n. sp. Side view of holotype (U.S.N.M. 104433) showing coiling in a single plane and even amount of overlap; ×105. (p. 247)

2a–b—*Trochamminoides coronus* Loeblich and Tappan. *2a*, Side view of hypotype (USNM 104435) showing numerous chambers and indistinct sutures in early portion; *2b*, edge view showing planispiral evolute coil; ×105. (p. 248)

3a–b—*Haplophragmoides globosa* Lozo. *3a*, Side view of hypotype (USNM 104436) showing indistinct sutures in umbonal region; *3b*, edge view showing globose test, involutely coiled with slight trochoid character; ×105. (p. 249)

4a–5—*Ammobaculites obliquus* Loeblich and Tappan. *4a*, Side view of hypotype (USNM 104443a) showing involute coil, oblique sutures and elongate terminal chamber; *4b*, edge view of hypotype; *5*, side view of smaller hypotype (USNM 104443b) showing lower chambers than in fig. *4a;* ×63. (p. 250)

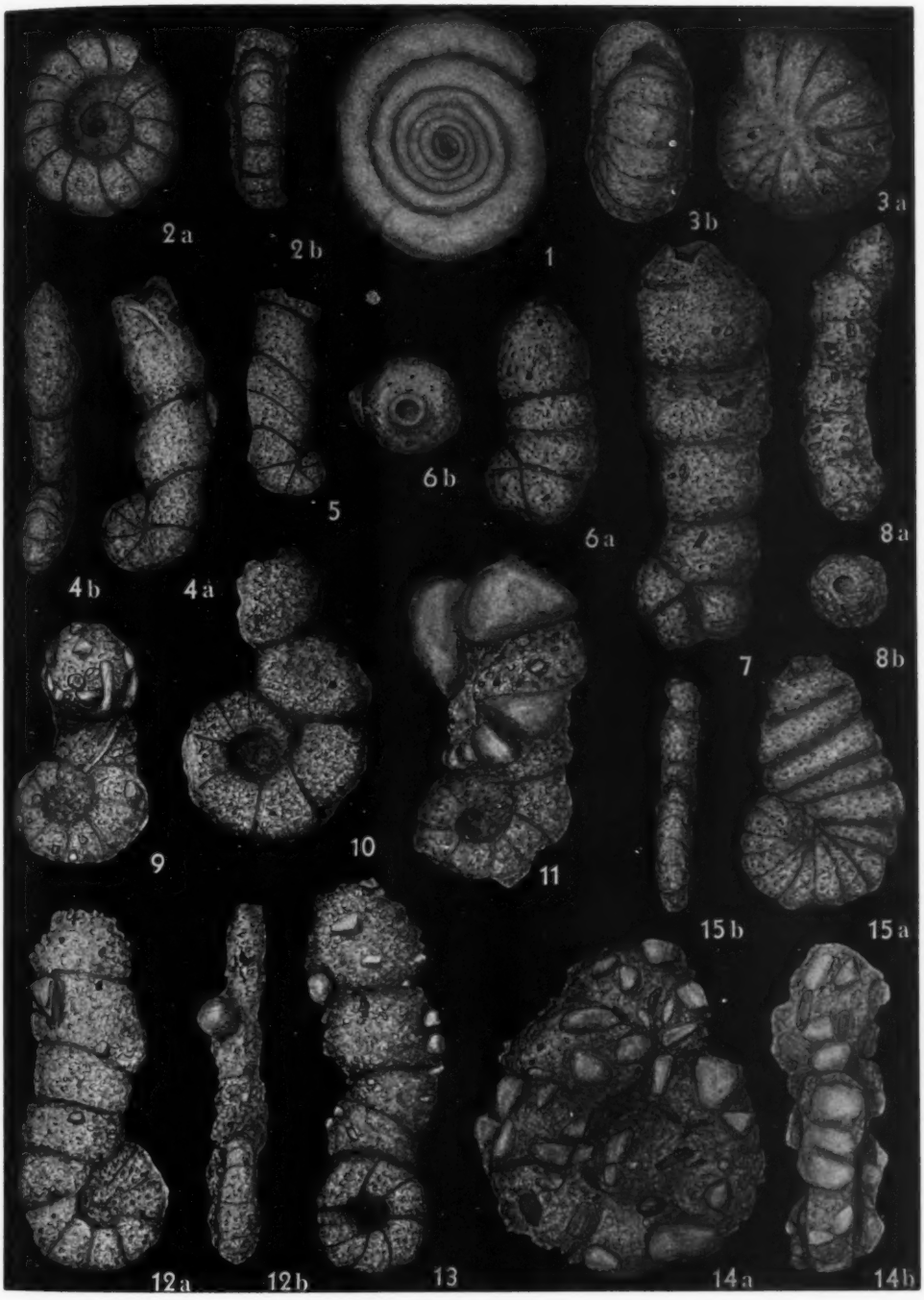
6a–7—*Ammobaculites torosus* Loeblich and Tappan, n. sp. *6a*, Side view of paratype (USNM 104448) showing involute coil with few, but inflated chambers and slight terminal neck; *6b*, top view showing terminal aperture; *7*, side view of holotype (USNM 104447); ×48. (p. 251)

8a–b—*Ammobaculites euides* Loeblich and Tappan. *8a*, side view of hypotype (USNM 104440), showing sub-cylindrical test; *8b*, top view showing rounded terminal aperture; ×48. (p. 250)

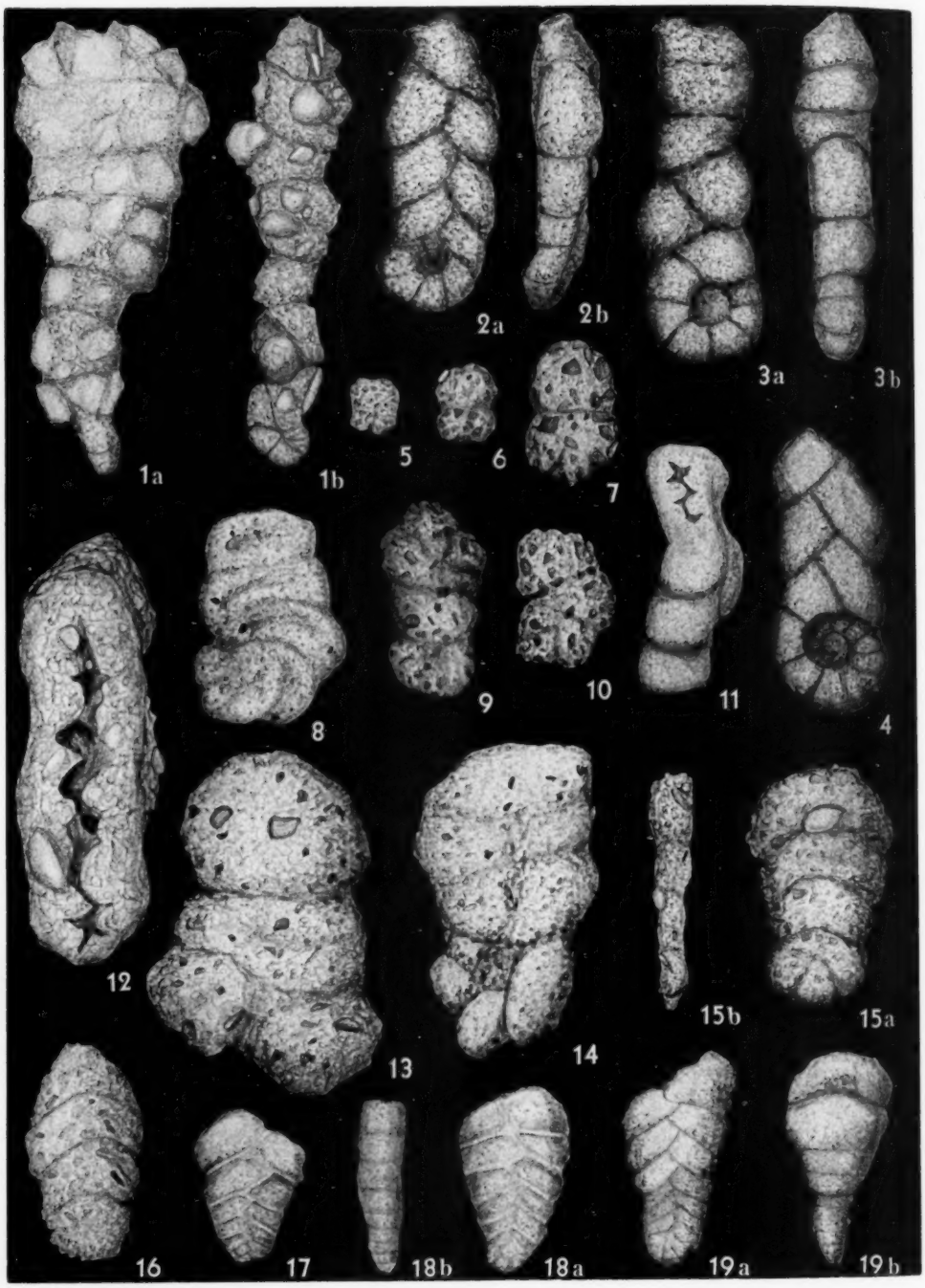
9–13—*Ammobaculites subcretaceus* Cushman and Alexander. *9*, side view of hypotype (USNM 104444b) showing evolute coil and fairly coarse grained wall; *10*, side view of hypotype (USNM 104445b) showing wall of fairly even texture; *11*, side view of hypotype (USNM 104444a) showing extremely large grains in wall of uniserial portion; *12a*, side view of hypotype (USNM 104445a) exhibiting more elongate uniserial portion; *12b*, edge view showing compressed character of test; *13*, side view of hypotype (USNM 104445c) showing wedge-shaped pseudo-biserial chambers in early uniserial portion and variability of grain size in the wall; All ×63. (p. 251)

14a–b—*Ammobaculites goodlandensis* Cushman and Alexander. *14a*, side view of hypotype (USNM 104442) showing indistinct sutures and extremely large grains forming the test; *14b*, side view of hypotype. ×48. (p. 250)

15a–b—*Ammomarginulina loricata* Loeblich and Tappan, n. sp. *15a*, side view of holotype (USNM 104438) showing partially evolute many-chambered coil and low chambers of uniserial portion; *15b*, edge view of holotype showing compressed character of test. ×27. (p. 249)



Loeblich and Tappan, Walnut clay Foraminifera



Loeblich and Tappan, Walnut clay Foraminifera

Genus HAPLOPHRAGMOIDES Cushman, 1910
HAPLOPHRAGMOIDES GLOBOSA Lozo
Plate 46, figures 3a, b

Haplophragmoides globosa Lozo, 1944, Amer. Midland Nat., vol. 31, no. 3, p. 543, pl. 2, figs. 8a–8c, text figs. 16A–B.

Test free, small, involutely coiled, periphery broad and rounded; chambers numerous, narrow, as many as 12 in the final whorl; sutures straight, somewhat obscure, the final two or three very slightly depressed; wall arenaceous, of moderately sized grains, surface somewhat roughened; aperture a low arch at the base of the apertural face.

Greatest diameter of hypotype 0.24 mm., least diameter 0.23 mm., greatest thickness 0.14 mm.

Types and occurrence.—Figured hypotype (USNM No. 104436), unfigured hypotypes (USNM No. 104437) and hypotypes (H. N. Loeblich Coll. 1096), all from the Walnut clay at locality HTL-74, Love County, Oklahoma.

Lozo described this species as occurring only in the upper Goodland marly material. We also have it in the basal 2.2 foot nodular and marly limestone of the Goodland, immediately overlying the Walnut clay at the above locality.

Genus AMMOMARGINULINA Wiesner, 1931
AMMOMARGINULINA LORICATA
Loeblich and Tappan, n. sp.
Plate 46, figures 15a, b

Test free, large, flattened, periphery broadly rounded; early portion coiled, about 12 low chambers visible in the coil, followed by about four broad low uniserial chambers; sutures of the coil are obscure except when specimens are dampened, those of the uniserial portion are slightly depressed; wall arenaceous, of medium-sized grains, with considerable cement; aperture terminal, rounded.

Length of holotype 1.27 mm., greatest breadth of coil, 0.74 mm., greatest breadth of uniserial portion 0.64 mm., greatest thickness 0.23 mm.

Types and occurrence.—Holotype (USNM No. 104438), paratypes (USNM No.

EXPLANATION OF PLATE 47

Lituolidae to Textulariidae

FIGS. *1a–b—Ammobaculites viriosus* Loeblich and Tappan, n. sp. *1a*, view of holotype (USNM 104449) showing peripheral view of coil and broad view of uniserial chambers; *1b*, view of holotype showing side view of coil and great variation in grain size of test. ×48. (p. 251)

2a–4—Ammobaculoides whitneyi (Cushman and Alexander). *2a*, side view of hypotype (USNM 104450c) showing tendency to uniserial development in the final chamber; *2b*, edge view of hypotype showing terminal aperture; *3a*, edge view of hypotype (USNM 104450a) showing less well developed biserial portion followed by three uniserial chambers; *3b*, edge view of hypotype; *4*, side view of hypotype (USNM 104450b). All ×105. (p. 252)

5–15b—Buccicrenata subgoodlandensis (Vanderpool). *5*, juvenile opotype (USNM 104457b); *6*, small juvenile topotype (USNM 104457d) showing single uniserial chamber; *7*, small topotype (USNM 104457e) showing indistinct coil and single uniserial chamber; *8*, lectotype (USNM 104455) showing indistinct chambers in coil followed by three uniserial chambers; *9*, topotype (USNM 104457h) showing small coil, two chambered uniserial portion with a slight neck on the terminal chamber; *10*, small topotype (USNM 104457f); *11*, hypotype (USNM 104460) showing elongate aperture with series of projecting lateral tooth-like processes; *12*, topotype (USNM 104457i) showing similar aperture in a coarsely arenaceous specimen; *13*, large topotype (USNM 104457c) showing indistinct coil and three chambered uniserial portion; *14*, topotype (USNM 104457g) showing more distinct chambers in coil, compression of test and three chambered uniserial portion; *15a*, topotype (USNM 104457a) showing coil followed by arched uniserial chambers; *15b*, side view of topotype to show compressed character of test. All side views ×10, apertural views ×22. (p. 253)

16—Flabellammina alexanderi Cushman. Side view of hypotype (USNM 104453) showing indistinct coil and arched uniserial chambers. ×22. (p. 252)

17–18b—Spiroplectammina goodlandana Lalicker. *17*, side view of hypotype (USNM 104467a) showing raised and limbate sutures; *18a*, side view of hypotype (USNM 104467b); *18b*, edge view of hypotype showing subequal thickness of entire test. × 105. (p. 254)

19a–b—Spiroplectammina alexanderi Lalicker. *19a*, Side view of hypotype (USNM 104466) showing oblique, slightly depressed sutures; *19b*, edge view of hypotype showing rapid increase in chamber thickness and more gradual increase in height. ×105. (p. 254)

104439), and paratypes (H. N. Loeblich Coll. No. 1098), all from the Walnut clay at locality HTL-105, Grayson County, Texas.

Remarks.—This species differs from *Ammomarginulina cuyleri* (Tappan) in the comparatively larger and broader coil, more evolute coil, in having about 12 chambers in the coil rather than only six, and in the much lower and broader uniserial chambers.

Genus AMMOBACULITES Cushman, 1910

AMMOBACULITES EUIDES
Loeblich and Tappan
Plate 46, figures 8a, b

Ammobaculites euides LOEBLICH and TAPPAN, 1949, Jour. Washington Acad. Sci., p. 90.

Test free, elongate, cylindrical, slightly arcuate; chambers numerous, about four to five in the coiled early portion followed by about five uniserial chambers; sutures straight, obscure in early portion, slightly constricted in the uniserial portion; wall arenaceous, of medium-sized grains, with considerable cement; aperature terminal, rounded.

Length of figured hypotype 0.83 mm., greatest breadth 0.21 mm.

Types and occurrence.—Figured hypotype (USNM No. 104440) and unfigured hypotypes (H. N. Loeblich Coll. 1099) all from the Walnut clay at locality HTL-74, Love County, Oklahoma. Unfigured hypotypes (USNM No. 104441 and H. N. Loeblich Coll. 1100) from the Walnut at locality HTL-105, Grayson County, Texas.

Remarks.—This species was originally described from the Kiowa shale of Kansas, also of Fredericksburg age.

AMMOBACULITES GOODLANDENSIS
Cushman and Alexander
Plate 46, figures 14a, b

Ammobaculites goodlandensis CUSHMAN and ALEXANDER, 1930, Contr. Cushman Lab. Foram. Res., vol. 6, no. 1, p. 8, pl. 2, figs. 7 and 8.

Ammobaculites goodlandensis Cushman and Alexander, TAPPAN, 1940, Jour. Paleontology, vol. 14, no. 2, p. 96, pl. 14, figs. 8a–9.

Ammobaculites goodlandensis Cushman and Alexander, TAPPAN, 1943, Jour. Paleontology, vol. 17, no. 5, p. 481, pl. 77, figs. 9a–b.

Ammobaculites goodlandensis Cushman and Alexander, Lozo, 1944, Amer. Midland Nat., vol. 31, no. 3, p. 537, pl. 4, fig. 4.

Test free, large, early portion close-coiled, centrally umbilicate, periphery truncate; chambers somewhat inflated, about eight in the last volution of the coil; followed by one or two uniserial chambers; sutures straight, slightly depressed, somewhat obscure in early portion; wall coarsely arenaceous, surface rough; aperture terminal.

Length of figured hypotype 0.99 mm., greatest breadth of coil 0.83 mm., greatest thickness 0.32 mm.

Types and occurrence.—Figured hypotype (USNM No. 104442), unfigured hypotypes (H. N. Loeblich Coll. 1101) all from the Walnut clay at locality HTL-74, Love County, Oklahoma.

Remarks.—This species seems slightly more flattened in the Walnut than in the Goodland from where it was originally described, and the chambers of the Walnut specimens are less inflated and angular.

AMMOBACULITES OBLIQUUS
Loeblich and Tappan
Plate 46, figures 4a–5

Ammobaculites obliquus LOEBLICH and TAPPAN, 1949, Jour. Washington Acad. Sci., p. 90.

Test free, small, early portion close coiled, later uncoiling, periphery rounded; chambers numerous, five to seven in the early involutely coiled portion increasing gradually in size as added, followed by up to four uniserial chambers; sutures distinct, depressed, straight or very slightly curved backwards at the periphery in the coil, at an oblique angle in the uniserial portion, highest dorsally, slightly arched upwards at the sides; wall arenaceous, of medium to fine grains, surface smoothly finished; aperture simple, terminal.

Length of larger hypotype 0.62 mm., greatest diameter of coil 0.21 mm., greatest breadth of uniserial portion 0.16 mm., greatest thickness 0.14 mm.

Types and occurrence.—Figured hypotypes (USNM Nos. 104443a–b), unfigured hypotypes (H. N. Loeblich Coll. 1102, 1104, and 1112), all from the Walnut clay at locality HTL-105, Grayson County, Texas.

Remarks.—This species was originally described from the Kiowa shale of Kansas.

AMMOBACULITES SUBCRETACEUS
Cushman and Alexander
Plate 46, figures 9–13

Ammobaculites subcretacea CUSHMAN and ALEXANDER, 1930, Contr. Cushman Lab. Foram. Res., vol. 6, no. 1, p. 6, pl. 2, figs. 9–10.
Ammobaculites subcretacea Cushman and Alexander, ALBRITTON, 1937, Jour. Paleontology, vol. 11, no. 1, p. 20, pl. 4, figs. 3–4.
Ammobaculites subcretaceus Cushman and Alexander, LOZO, 1944, Amer. Midland Nat., vol. 31, no. 3, p. 538, pl. 4, figs. 2–3.

Test free, elongate, flattened, early portion close coiled, slightly concave in the umbilical region, slightly evolute, so that part of the preceding coils are visible, periphery rounded; eight to nine chambers in the coil, increasing gradually in size as added, followed by as many as four uniserial chambers, which increase very little in diameter, chambers widest near the base; sutures generally obscure in the early portion, occasionally slightly depressed, generally somewhat depressed in the uncoiled portion, the first one or two uncoiled chambers may be slightly wedge-shaped, with the sutures oblique, giving a sub-biserial appearance, although never reaching a definite biseriality before becoming completely rectilinear, later sutures straight; wall arenaceous, of fine to medium-sized grains; aperture terminal, elongate.

Length varies from 0.53 to 0.85 mm., greatest breadth of coils vary from 0.23 to 0.39 mm.

Types and occurrence.—Figured hypotypes of figures 9 and 11 (USNM Nos. 104444a–b) and unfigured hypotypes (H. N. Loeblich Coll. 1105) from the Walnut clay at locality HTL-74, Love County, Oklahoma. Hypotypes of figures 10, 12 and 13 (USNM Nos. 104445a–c), unfigured hypotypes (USNM Nos. 104446) and unfigured hypotypes (H. N. Loeblich Coll. 1106) all from the Walnut clay at locality HTL-105, Grayson County, Texas.

AMMOBACULITES TOROSUS
Loeblich and Tappan, n. sp.
Plate 46, figures 6a–7

Test free, large, elongate, early portion close coiled and involute, later portion uniserial, cylindrical; chambers inflated, about four in the coil, followed by three to four uniserial chambers, increasing in height as added, last chamber about twice the height of earlier uniserial chambers, and subpyriform in outline, being produced terminally into a short neck; sutures distinct, depressed, straight; wall arenaceous, of medium sized grains with considerable cement, surface rather smoothly finished; aperture rounded, terminal, surrounded by a slight lip.

Length of holotype 1.15 mm., greatest breadth of coil 0.35 mm., greatest breadth of last chamber 0.39 mm.; length of figured paratype 0.64 mm., greatest breadth of coil 0.28 mm., greatest breadth of uniserial portion, 0.28 mm.

Types and occurrence.—Holotype (USNM No. 104447) figured paratype (USNM No. 104448) and unfigured paratypes (H. N. Loeblich Coll. 1107) all from the Walnut clay at locality HTL-105, Grayson County, Texas.

Remarks.—This species is somewhat similar to *Ammobaculites euides* Loeblich and Tappan, but is considerably larger, with more inflated chambers, and the coiled portion is larger in diameter than the earliest uniserial chambers, with the test then increasing gradually in diameter. In *A. euides* the test is nearly cylindrical.

AMMOBACULITES VIRIOSUS Loeblich
and Tappan n. sp.
Plate 47, figures 1a, b

Test free, large elongate, early portion close coiled, later uniserial and flaring somewhat; about six chambers which flare rapidly in a plane perpendicular to the plane of coiling of the early portion, uniserial chambers not as high as broad; sutures depressed, slightly constricted, straight; wall arenaceous, of fine to medium sized grains in the coil, but more coarsely arenaceous in the uniserial portion; aperture terminal, elongate.

Length of holotype 1.27 mm., greatest breadth of coil 0.21 mm., greatest thickness of coil 0.12 mm., greatest diameter of uniserial portion 0.60 mm., least diameter 0.32 mm. Other specimens from 0.99 mm. to 1.57 mm. in length.

Types and occurrence.—Holotype (USNM No. 104449) and unfigured paratypes (H. N. Loeblich Coll. 1108 and 1109) all from

the Walnut clay, at locality HTL-105, Grayson County, Texas.

Remarks.—This species most closely resembles *Ammobaculites testacea* Tappan, but is nearly twice as large, has a more involute early coil, and a more flaring test.

Genus AMMOBACULOIDES Plummer, 1932
AMMOBACULOIDES WHITNEYI
(Cushman and Alexander)
Plate 47, figures 2a–4

Spiroplectammina whitneyi CUSHMAN and ALEXANDER, 1930, Contr. Cushman Lab. Foram. Res., vol. 6, no. 1, p. 8, pl. 2, figs. 12a–b.
Spiroplectammina cf. *whitneyi* Cushman and Alexander, Lozo, 1944, Amer. Midland Nat. vol. 31, no. 3, p. 551.

Test free, small, elongate, flattened, early portion coiled, centrally umbilicate, later biserial, and finally uniserial, sides nearly parallel, periphery rounded; chambers numerous, six to eight in the last volution of the coil, followed by two to six biserially arranged chambers, and finally by two to three uniserial chambers; sutures distinct, depressed, straight; wall finely arenaceous, surface smoothly finished; aperture terminal, elliptical.

Length varies from 0.30 mm. to 0.55 mm., greatest breadth of coil from 0.09 to 0.21 mm.

Types and occurrence.—Figured hypotypes (USNM Nos. 104450 a-c), unfigured hypotypes (USNM Nos. 104451–104452, and H. N. Loeblich Coll. 1110 and 1111) all from the Walnut clay, at locality HTL-105, Grayson County, Texas.

Remarks.—This species was originally described from the Goodland formation by Cushman and Alexander as belonging to *Spiroplectammina* although they noted the terminal aperture. The holotype shows a development similar to two of the specimens herein illustrated (figures 2 and 4), but all gradations are present from the terminally biserial forms to those with definite uniserial chambers.

Lozo (1944, p. 551) did not recognize this species in his Goodland material and doubtfully reported it from one Kiamichi sample restricted to one locality. The writers record it as common in both Goodland and Kiamichi formations. Many of our Goodland slides have considerably over 100 specimens of this species.

Genus FLABELLAMMINA Cushman, 1928
FLABELLAMMINA ALEXANDERI Cushman
Plate 47, figure 16

Flabellammina alexanderi CUSHMAN, 1928, Contr. Cushman Lab. Foram. Res., vol. 4, no. 1, p. 1, pl. 1, figs. 3–4.
Flabellammina alexanderi Cushman, ALEXANDER, 1928, Jour. Paleontology, vol. 2, no. 1, p. 43, test figs. 1, 2.
Flabellammina alexanderi Cushman, PLUMMER, 1931, Univ. Texas Bull., no. 3101, p. 126.
Flabellammina alexanderi Cushman, ALEXANDER and SMITH, 1932, Jour. Paleontology, vol. 6, no. 4, p. 300, pl. 45, figs. 1–5, 15.
Flabellammina alexanderi Cushman, Lozo, 1944, Amer. Midland Nat., vol. 31, no. 3, p. 541, pl. 4, figs. 15–16.

Test free, large, roughly ovate in outline, flattened, early portion coiled, later uniserial; chambers numerous, indistinct in the coil, later uniserial ones chevron-shaped, broad and low; sutures generally indistinct, arched centrally in the later portion; wall arenaceous, of very large grains in a groundmass of finer material; aperture terminal, elliptical.

In the Walnut material this species varies in length from 0.81 mm. to 1.38 mm., and in greatest breadth varies from 0.51 mm. to 0.85 mm.

Types and occurrence.—Figured hypotype (USNM No. 104453), and unfigured hypotypes (USNM No. 104454, and H. N. Loeblich Coll. 1114) all from the Walnut clay, at locality HTL-74, Love County, Oklahoma.

Subfamily LITUOLINAE
Genus BUCCICRENATA Loeblich and Tappan, n. gen.

Genotype: *Ammobaculites subgoodlandensis* Vanderpool

Ammobaculites of Vanderpool 1933; (part) of Lozo 1944.

Derived from *bucca* L., mouth cavity+*crenatus* L., notched.

Test flattened, planispiral in early stages, later portion uncoiled and straight, interior labyrinthic; wall arenaceous; aperture in early stages at base of apertural face, later terminal, elongate with a series of lateral tooth-like projections.

Buccicrenata differs from *Lituola* in possessing an elongate, crenulate aperture instead of a cribrate one and from *Polychasm-*

mina in being initially planispirally coiled and in lacking the interrupted slit-like aperture of the latter.

BUCCICRENATA SUBGOODLANDENSIS
(Vanderpool)
Plate 47, figures 5–15b

Ammobaculites subgoodlandensis VANDERPOOL, 1933, Jour. Paleontology, vol. 7, no. 4, p. 407, pl. 49, figs. 1–3.
Ammobaculites subgoodlandensis Vanderpool, Lozo, 1944, Amer. Midland Nat., vol. 31, no. 3, p. 540, pl. 1, figs. 2–3; pl. 4, fig. 1, text figs. 15A–G.

Test free, large, flattened, periphery rounded; early coiled portion with two to five chambers, later uniserial portion with as many as three chambers, chambers frequently collapsed centrally; sutures may be slightly depressed, but in many specimens are somewhat obscure, except where constriction at the margins of the test give a lobulate periphery; wall arenaceous, consisting of very large grains in a ground mass of finer arenaceous material, interior labyrinthic; aperture in the early coiled portion at the base of the apertural face, terminal in the uniserial portion consisting of a slit-like opening with infolded lateral projections from the sides into the apertural opening.

This species varies in length from 0.71 mm. (juvenile forms) to 4.73 mm. Length of specimen in figure 15, 3.26 mm., greatest breadth of coil 1.38 mm., greatest thickness 0.58 mm.

Types and occurrence.—Lectotype (USNM No. 104455) specimen figured by Vanderpool (1933, pl. 49, fig. 1), paratypes (USNM No. 104456), figured topotypes (USNM Nos. 104457 a-i), unfigured topotypes (USNM No. 104458), and unfigured topotypes (Loeblich Coll. No. 1097) all from the Walnut clay at locality HTL-74, Love County, Oklahoma; Walnut clay (Hypotypes USNM No. 104459, H. N. Loeblich Coll. Nos. 1103, 1113) at locality HTL-105, Grayson County, Texas; figured hypotype (USNM No. 104460) from the upper Goodland formation, in a low bluff on the east bank of the North Fork of Mary's Creek, at the concrete bridge on the Fort Worth-Weatherford Highway, 11½ miles west of Fort Worth, Tarrant County, Texas.

Remarks.—This species varies in wall character with a variation in lithology of the enclosing strata. In the type locality it is very coarsely arenaceous, but in the Goodland locality mentioned above the coarse grains are lacking, the entire test being of more homogeneous character and of medium-sized grains throughout. The tests are also quite variable in size and outline, all gradations occurring from very tiny juvenile forms to quite large adults. A fairly comprehensive series is shown by the illustrations.

Genus LITUOLA Lamarck, 1804
LITUOLA SUBGOODLANDENSIS (Vanderpool)
Plate 48, figures 1–7

Reophax subgoodlandensis VANDERPOOL, 1933, Jour. Paleontology, vol. 7, no. 4, p. 407, pl. 49, figs. 4–6.
Lituola inflata LOZO, 1944, Amer. Midland Nat., vol. 31, no. 3, p. 547, pl. 1, figs. 1a–b.
Not *Lituola* (*Haplophragmium*) *inflata* Reuss, WRIGHT, 1875, Rept. Proc. Belfast Nat. Field Club, n.s., vol. 1, App. 3, p. 82.

Test free, large, elongate, early portion planispiral, later uniserial and rectilinear or slightly curved, rounded in section; early coiled portion consisting of only two to three chambers, the division between chambers sometimes obscure, so that the test appears to be wholly uniserial; chambers increasing rapidly in size, so that the test is frequently flared; sutures obscure in the coil, distinct, straight and depressed in the rectilinear portion; wall very coarsely arenaceous, some grains up to 0.53 mm. across, the amount of cement variable, in some specimens filling the spaces between grains to give a fairly level surface, in other specimens the cement is not even visible between the grains when viewed from the exterior, so that the surface may be extremely rough; aperture terminal, cribrate.

Length up to 5.78 mm.

Types and occurrence.—The lectotype (USNM No. 104461) is here designated as the specimen illustrated by Vanderpool (1933) on plate 49, figure 4, as no specimen on his slide was designated as holotype. Paratypes (USNM No. 104462) are figures 5 and 6 of Vanderpool. Figured topotypes (USNM Nos. 104463 a-f), unfigured topotypes (USNM No. 104464 and H. N. Loeblich Coll. 1115) all from the Walnut

clay at locality HTL-74, Love County, Oklahoma. Unfigured hypotypes (USNM No. 104465 and Loeblich Coll. 1116 and 1117) from the Walnut clay at locality HTL-105, Grayson County, Texas.

Remarks.—This species, originally described by Vanderpool as a *Reophax*, is very abundant at the type locality, being represented in our collections by well over 100 specimens, and well preserved specimens exhibit the terminal cribrate aperture and early two or three chambered loose coil. Two of Vanderpool's type specimens exhibit this loose coil. It is undoubtedly the same species as that described by Lozo from the Kiamichi formation, of which we also have a large series of topotypes. *Lituola edwardsensis* Ikins and Clabaugh is a related species if not identical with *L. subgoodlandensis* (Vanderpool). No distinctions can be made on the basis of the illustrations, although we have not seen topotypes. The great similarity and close stratigraphic position would, however, suggest their relationship.

Family TEXTULARIIDAE
Subfamily SPIROPLECTAMMININAE
Genus SPIROPLECTAMMINA Cushman, 1927
SPIROPLECTAMMINA ALEXANDERI Lalicker
Plate 47, figures 19a–b

Spiroplectammina alexanderi LALICKER, 1935, Contr. Cushman Lab. Foram. Res., vol. 11, no. 1, p. 1, pl. 1, figs. 1a–c.
Spiroplectammina alexanderi Lalicker, LOZO, 1944, Amer. Midland Nat., vol. 31, no. 3, p. 548, pl. 4, fig. 6.

Test free, very small, initial end rounded, flattened, planispiral, later portion biserial, flaring and nearly circular in end view; chambers numerous and low, higher at the median line, sloping down to the margins of the test, increasing rapidly in thickness as added, more gradually in height and breadth; sutures distinct, depressed; wall finely arenaceous; aperture low and broad, at the base of the last formed chamber.

Length of figured hypotype 0.28 mm., greatest breadth 0.15 mm., greatest thickness 0.16 mm.

Types and occurrence.—Figured hypotype (USNM No. 104466), and unfigured hypotypes (H. N. Loeblich Coll. 1118) all from the Walnut clay at locality HTL-74, Love County, Oklahoma.

SPIROPLECTAMMINA GOODLANDANA Lalicker
Plate 47, figures 17–18b

Spiroplectammina goodlandana LALICKER, 1935, Contr. Cushman Lab. Foram. Res., vol. 11, pt. 1, p. 2, pl. 1, figs. 2–3.
Spiroplectammina goodlandana Lalicker, LOZO, 1944, Amer. Midland Nat., vol. 31, no. 3, p. 549, pl. 4, fig. 5.

Test free, small, flattened early portion coiled, later biserial, periphery bluntly rounded; early chambers coiled, later biserial chambers low and broad, increasing gradually in height; sutures distinct, raised, limbate, straight; wall finely arenaceous with much cement; aperture an arch at the base of the last-formed chamber.

Length varies from 0.19 mm. to 0.28 mm., breadth varies from 0.14 to 0.16 mm.

Types and occurrence.—Figured hypotypes (USNM Nos. 194467a–b) and unfigured hypotypes (H. N. Loeblich Coll. 1119) both from the Walnut clay at locality HTL-74, Love County, Oklahoma.

Subfamily TEXTULARIINAE
Genus TEXTULARIA Defrance, 1824
TEXTULARIA RIOENSIS Carsey
Plate 48, figure 11

Textularia sp. CARPENTER, 1925, Univ. Texas Bull. 2544, pl. 17, fig. 15.
Textularia rioensis CARSEY, 1926, Univ. Texas Bull. 2612, p. 24, pl. 7, fig. 12.
Textularia conica d'Orbigny, CARSEY, 1926 (not d'Orbigny), Univ. Texas Bull. 2612, p. 23, pl. 7, fig. 1.
Textularia rioensis Carsey, PLUMMER, 1931, Univ. Texas Bull. 3101, p. 128, pl. 8, fig. 6.
Textularia rioensis Carsey, TAPPAN, 1940, Jour. Paleontology, vol. 14, no. 2, p. 98, pl. 14, figs. 1a–2b.
Textularia rioensis Carsey, TAPPAN, 1943, Jour. Paleontology, vol. 17, no. 5, p. 485, pl. 78, figs. 1a–4.
Textularia rioensis Carsey, LOZO, 1944, Amer. Midland Nat., vol. 31, no. 3, p. 551, pl. 3, figs. 7, 9a–b.

Test free, flaring, biserial, periphery rounded; chambers low and broad; sutures distinct, depressed, straight; wall finely arenaceous, surface smooth; aperture an arch at the base of the last-formed chamber.

Length of specimens in the Walnut varies from 0.23 mm. to 0.51 mm., greatest breadth varies from 0.25 mm. to 0.39 mm.

Types and occurrence.—Figured hypotype (USNM No. 104468) unfigured hypotypes (USNM No. 104469, and H. N. Loeblich

Coll. 1120) all from the Walnut clay at locality HTL-74, Love County, Oklahoma.

Family VERNEUILINIDAE
Genus VERNEUILINOIDES Loeblich and Tappan, 1949
VERNEUILINOIDES SCHIZEA (Cushman and Alexander)
Plate 48, figures 9–10

Verneuilina schizea CUSHMAN and ALEXANDER, 1930, Contr. Cushman Lab. Foram. Res., vol. 6, pt. 1, p. 9, pl. 2, figs. 13–14.
Verneuilina schizea Cushman and Alexander, CUSHMAN, 1933, Cushman Lab. Foram. Res., Spec. Publ. 5, pl. 7, figs. 21a–b.
Verneuilina schizea Cushman and Alexander, CUSHMAN, 1937, Cushman Lab. Foram. Res., Spec. Publ. 7, p. 8, pl. 1, figs. 5–6.
Verneuilina schizea Cushman and Alexander, Lozo, 1944, Amer. Midland Nat., vol. 31, no. 3, p. 550, pl. 3, fig. 6.

Test free, elongate, tapering at the base, widest at the base of the last whorl of chambers at the apertural end; chambers distinct and inflated, giving a lobulate outline to the test; sutures distinct, deeply depressed, wall finely arenaceous, surface smooth; aperture at the inner margin of the last formed chamber.

Length varies from 0.25 mm. to 0.46 mm., breadth from 0.14 mm. to 0.22 mm.

Types and occurrence.—Figured hypotypes (USNM No. 104470), and unfigured hypotypes (USNM No. 104471 and H. N. Loeblich Coll. No. 1121), all from the Walnut clay at locality HTL-74, Love County, Oklahoma.

Remarks.—Lozo (1944, p. 550) stated that when topotypes were dissolved in hydrochloric acid there was little or no residue, and he suggested that possibly the test was originally hyaline, rather than arenaceous as originally defined. The writers have found that many of the agglutinated species in the Lower Cretaceous are almost completely soluble in acid, but this is due to the agglutinated material consisting of calcareous rather than siliceous particles. The present species seems to be similar in character, and definitely agglutinated.

Lozo also stated that the species was abundant in marls and clay-marls but rare or absent in quartz-bearing deposits. We have found it in considerable abundance in the lower Goodland, immediately overlying the Walnut, at the Marietta locality where the Goodland is very sandy in character.

VERNEUILINOIDES sp.
Plate 48, figure 8

Gaudryinella delrioensis Plummer, TAPPAN, 1943 (not Plummer), Jour. Paleontology, vol. 17, no. 5, p. 490, pl. 78, fig. 30.

Test small, elongate, triserial, chambers increase rapidly in size, much inflated, subglobular; sutures distinct and much depressed; wall finely arenaceous; aperture at the base of the last-formed chamber.

Length of figured specimen 0.44 mm., greatest diameter 0.16 mm.

Types and occurrence.—Figured specimen (USNM No. 104472) from the Walnut clay, at locality HTL-74, Love County, Oklahoma.

Remarks.—This species is the same as that referred to *Gaudryinella delrioensis* by Tappan, 1943 (p. 490), from the Duck Creek formation, but is not the same as the true *G. delrioensis* of Plummer. It is quite rare, being represented in our Walnut material by the single specimen figured, and is also rare in the Duck Creek, where Tappan (1943, p. 490) stated that "the Duck Creek specimens are generally small, none with a truly uniserial development having been observed." The present species is represented only by triserial chambers, the test flares more than typical *G. delrioensis* and the chambers are not as nodose. It differs from *Verneuilinoides schizea* (Cushman and Alexander) in being more slender, in having more angular and inflated chambers, and in having a less smoothly finished exterior.

Family MILIOLIDAE
Genus QUINQUELOCULINA d'Orbigny, 1826
QUINQUELOCULINA MINIMA Tappan
Plate 48, figures 12a–13b

Quinqueloculina minima TAPPAN, 1943, Jour. Paleontology, vol. 17, no. 5, p. 490, pl. 78, figs. 33a–b.

Test free, tiny, ovate in outline, periphery rounded; chambers quite thick, arranged in a quinqueloculine pattern; sutures distinct, depressed; wall calcareous, imperforate surface smooth; aperture simple, at the end of the chamber, no tooth visible.

Length of figured hypotypes 0.16 mm. and 0.23 mm.

Types and occurrence.—Figured hypotypes (USNM Nos. 104473a–b) from the

Walnut clay, at locality HTL-74, Love County, Oklahoma. It was originally described from the Duck Creek formation (Washita group).

Family TROCHAMMINIDAE
Subfamily TROCHAMMININAE
Genus TROCHAMMINA Parker and Jones, 1859
TROCHAMMINA DEPRESSA Lozo
Plate 49, figures 1a-2

Trochammina depressa Lozo, 1944, Amer. Midland Nat., vol. 31, no. 3, p. 552, pl. 2, figs. 4a–b, 5.

Test free, small, compressed, trochoid, periphery lobulate; all chambers visible dorsally, only the six to seven of the last whorl visible ventrally, increasing rapidly in size, as added; sutures somewhat obscure, but constricted at the margin to give a lobulate periphery; wall finely arenaceous; aperture small, at the base of the apertural face of the last-formed chamber.

Greatest diameter of larger hypotype 0.51 mm., least diameter 0.38 mm., greatest thickness 0.09 mm.; greatest diameter of smaller hypotype 0.30 mm., least diameter 0.24 mm.

Types and occurrence.—Hypotype of figure 1 (USNM No. 104474a), hypotype of figure 2 (USNM No. 104474b), and unfigured hypotypes (H. N. Loeblich Coll. 1122) all from the Walnut clay, at locality HTL-74, Love County, Oklahoma.

Remarks: This species was originally described from the Kiamichi formation, where it is quite abundant in carbonaceous shales. It is rare in the Walnut clay concentrates.

Family LAGENIDAE
Subfamily NODOSARIINAE
Genus LENTICULINA Lamarck, 1804
LENTICULINA sp.
Plate 49, figures 3a–b

Test free, small, planispirally coiled, periphery acute; about nine chambers visible, increasing regularly in size; sutures straight or very slightly curved backwards at the periphery; wall calcareous, finely perforate, surface smooth; aperture radiate at the peripheral angle.

Greatest diameter of figured specimen 0.30 mm., least diameter 0.21 mm., greatest thickness 0.12 mm.

Types and occurrence.—Figured specimen (USNM No. 104475) from the Walnut clay, at locality HTL-74, Love County, Oklahoma. This form is too rare in the Walnut for specific determination.

Genus MARGINULINA d'Orbigny, 1826
MARGINULINA sp.
Plate 49, figures 4–5b

Test free, planispirally coiled at the base, then uncoiling; chambers broad and low, highest dorsally; sutures depressed, slightly curved; wall calcareous, finely perforate, surface smooth; aperture terminal, radiate.

Length varies from 0.30 mm. to 0.41 mm., greatest breadth from 0.12 to 0.16 mm.

Types and occurrence.—Figured specimens (USNM No. 104476a–b), and unfigured specimens (H. N. Loeblich 1123) from the Walnut clay at locality HTL-74, Love County, Oklahoma. This form is not sufficiently abundant for specific determination.

EXPLANATION OF PLATE 48

Lituolidae to Miliolidae

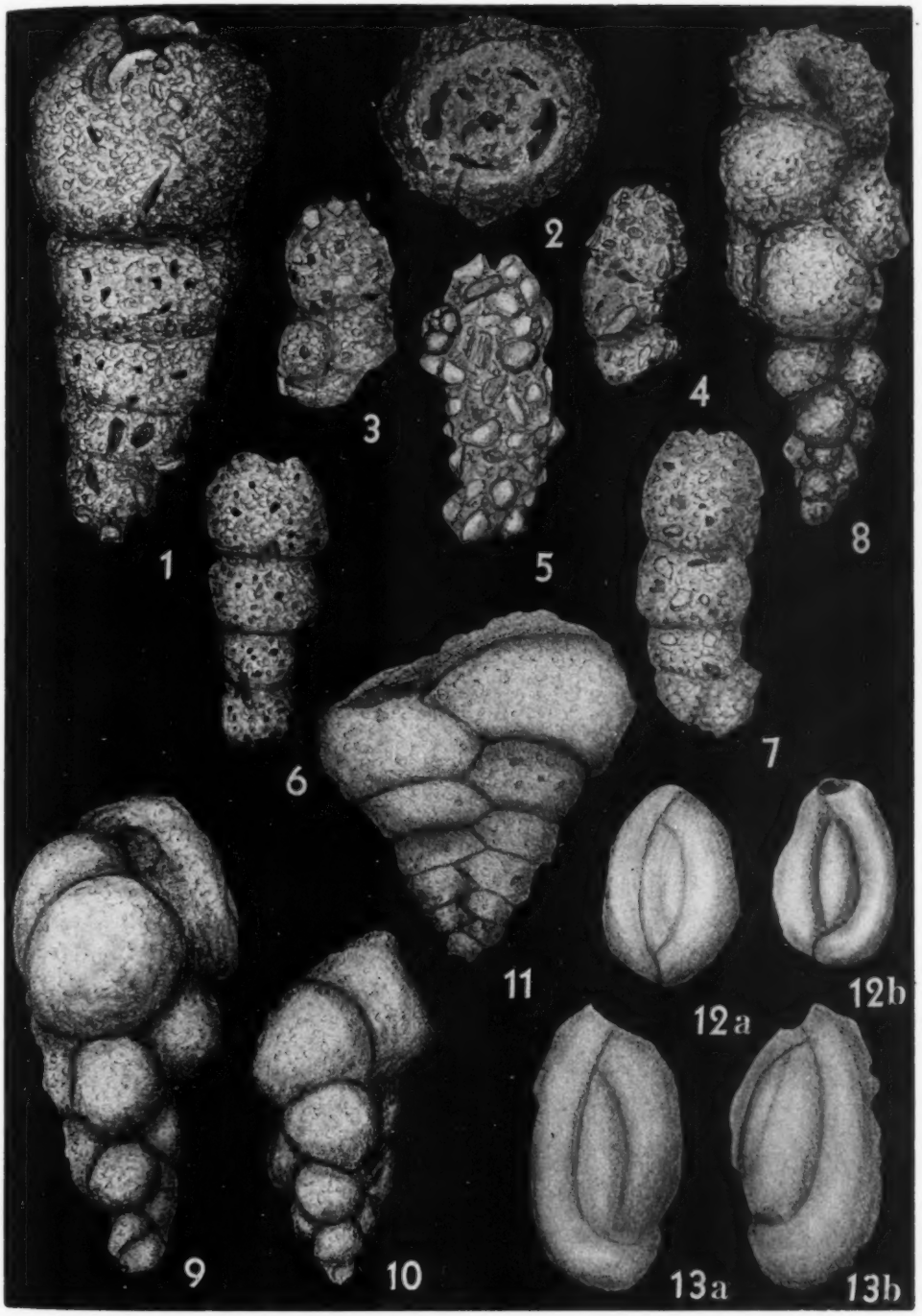
FIGS. *1–7—Lituola subgoodlandensis* (Vanderpool), *1*, Microspheric topotype (USNM 104463f) showing large flaring test; *2*, top view of topotype (USNM 104463b) showing multiple apertures; *3*, side view of small topotype (USNM 104463e) showing indistinct coil and short uniserial portion; *4*, small topotype (USNM 104463c); *5*, topotype (USNM 104463d) showing very coarse grains composing the test; *6*, lectotype (USNM 104461); *7*, topotype (USNM 104463a) showing indistinct three-chambered coil. ×15. (p. 253)

8—Verneuilinoides sp. Figured specimen (USNM 104472) showing narrow elongate triserial test. ×158. (p. 255)

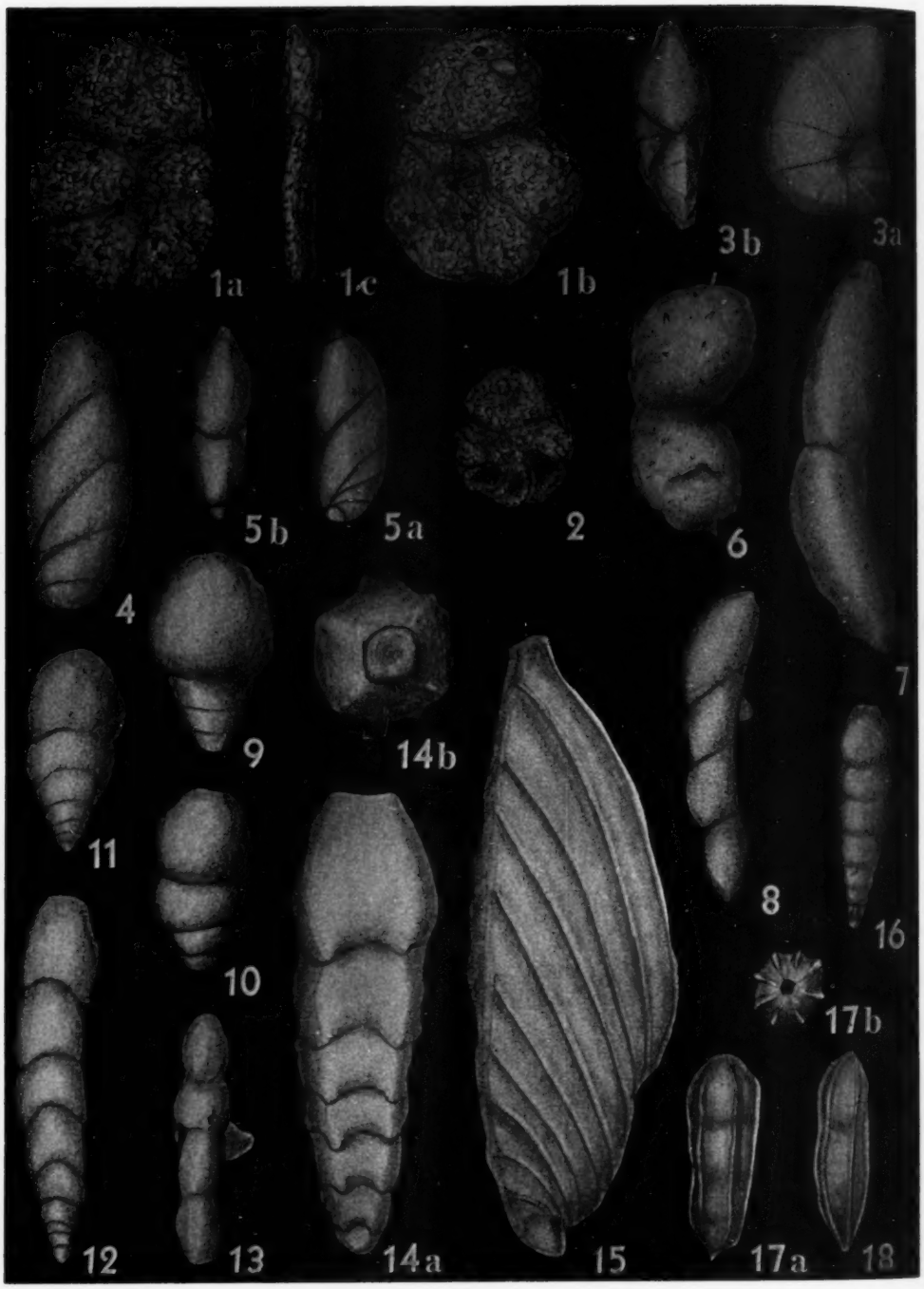
9–10—Verneuilinoides schizea (Cushman and Alexander). *9*, Side view of hypotype (USNM 104470a) showing tapering triserial test; *10*, side view of hypotype (USNM 104470b). ×158. (p. 255)

11—Textularia rioensis Carsey. *11*, Side view of hypotype (USNM 104468) showing flaring test and low chambers. ×158. (p. 254)

12a–13b—Quinqueloculina minima Tappan. *12a*, Side view of hypotype (USNM 104473a); *12b*, opposite side of hypotype; *13a*, side view of hypotype (USNM 104473b); *13b*, opposite side of hypotype. ×158. (p. 255)



Loeblich and Tappan, Walnut clay Foraminifera



Loeblich and Tappan, Walnut clay Foraminifera

Genus DENTALINA d'Orbigny, 1826

DENTALINA Sp. A

Plate 49, figure 8

Test free, elongate, arcuate; chambers numerous, length somewhat greater than breadth; sutures distinct, depressed, oblique; wall calcareous, finely perforate, surface smooth; aperture terminal, radiate.

Length varies from 0.41 mm. to 0.46 mm., greatest breadth varies from 0.09 to 0.12 mm.

Types and occurrence.—Figured specimen (USNM No. 104477) and unfigured specimens (H. N. Loeblich 1124) all from the Walnut clay at locality HTL-74, Love County, Oklahoma.

DENTALINA Sp. B

Plate 49, figure 6

Test free, elongate, slightly curved, consisting of two subglobular chambers; sutures distinct, much constricted; wall calcareous, finely perforate, surface finely hispid; aperture obscure.

Length varies from 0.21 to 0.30 mm., greatest breadth of chambers varies from 0.12 to 0.16 mm.

Types and occurrence.—Figured specimen (USNM No. 104478) and unfigured specimens (H. N. Loeblich Coll. 1125) all from the Walnut clay at locality HTL-74, Love County, Oklahoma.

DENTALINA CUCUMIS Loeblich and Tappan, n. sp.

Plate 49, figure 7

Test free, elongate, arcuate, consisting of two narrow and elongate chambers, each chamber about twice as long as broad; suture slightly constricted; wall calcareous, finely perforate, surface smooth; aperture terminal, radiate, at the end of a slight neck.

Length of holotype 0.58 mm., greatest breadth of chamber 0.13 mm.; other specimens from 0.46 to 0.53 mm. in length.

Types and occurrence.—Holotype (USNM No. 104479) and unfigured paratypes (H. N. Loeblich Coll. 1126) all from the Walnut clay at locality HTL-74, Love County, Oklahoma.

Remarks.—This species is similar in the elongate narrow chambers, to *Dentalina consobrina* d'Orbigny, but is considerably smaller, and the chambers are not as long

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EXPLANATION OF PLATE 49

Trochamminidae to Lagenidae

FIGS. *1a–2—Trochammina depressa* Lozo. *1a*, ventral view of hypotype (USNM 104474a) showing indistinct sutures; *1b*, dorsal view of hypotype; *1c*, edge view of hypotype; *2*, dorsal view of immature hypotype (USNM 104474b); ×72. (p. 256)

3a–b—Lenticulina sp. *3a*, side view of figured specimen (USNM 104475); *3b*, edge view; ×95. (p. 256)

4–5b—Marginulina sp. *4*, side view of figured specimen (USNM 104476a) showing strongly oblique sutures; *5a*, side view of figured specimen (USNM 104476b); *5b*, edge view; ×95. (p. 256)

6—Dentalina sp. B. Side view of figured specimen (USNM 104478); ×158. (p. 257)

7—Dentalina cucumis Loeblich and Tappan, n. sp. Side view of holotype (USNM 104479) showing typical two-chambered form; ×95. (p. 257)

8—Dentalina sp. A. Side view of figured specimen (USNM 104477); ×95. (p. 257)

9–10—Pseudoglandulina cf. *mutabilis* (Reuss). *9*, side view of hypotype (USNM 104486a) showing large amount of overlap of last chamber; *10*, side view of hypotype (USNM 104486b) showing more inflated early chambers; ×95. (p. 258)

11–12—Lingulina furcillata Berthelin. *11*, side view of hypotype (USNM 104488a) showing flattened, slightly flaring test; *12*, side view of hypotype (USNM 104488b) showing a narrower and more elongate form than in fig. *11*; ×95. (p. 259)

13—Nodosaria sp. Side view of figured specimen (USNM 104485); ×95. (p. 258)

14a–b—Quadratina euthemon Loeblich and Tappan, n. sp. *14a*, side view of holotype (USNM 104492) showing subangular form and downward projecting sutures at the angles; *14b*, top view of holotype showing subquadrate cross-section; ×158. (p. 259)

15—Citharina intumescens (Reuss). Side view of hypotype (USNM 104490) showing broad test with strongly oblique sutures; ×72. (p. 259)

16—Nodosaria rigentia Loeblich and Tappan, n. sp. Side view of holotype (USNM 104483) showing tapering test and inflated chambers; ×95. (p. 258)

17a–18—Nodosaria ithystoecha Loeblich and Tappan, n. sp. *17a*, Side view of holotype (USNM 104480) showing obscure sutures and low vertical ribs; *17b*, apertural view of holotype; *18*, side view of paratype (USNM 104481); ×95. (p. 258)

in proportion. No specimens of more than two chambers have been seen, and the specimens do not seem to be fragments of a more elongate form.

Genus NODOSARIA Lamarck, 1812
NODOSARIA ITHYSTOECHA Loeblich and Tappan, n. sp.
Plate 49, figures 17a–18

Test free, elongate, narrow, rectilinear; chambers increasing in height as added, up to six or seven in well-developed specimens; sutures not constricted but shown as slightly darker lines on the test, straight; wall calcareous, finely perforate, surface ornamented by about eight longitudinal ribs which continue unbroken across the sutures; aperture simple, terminal.

Length of holotype 0.30 mm., diameter 0.12 mm., length of figured paratype 0.30 mm., diameter 0.09 mm. Other specimens vary in length from 0.25 mm. to 0.46 mm.

Types and occurrence.—Holotype (USNM No. 104480), and figured paratype (USNM No. 104481), both from the Walnut clay at locality HTL-74, Love County, Oklahoma. Unfigured paratypes (USNM No. 104482 and H. N. Loeblich Coll. 1127 and 1128) all from the Walnut clay at locality HTL-105, Grayson County, Texas.

Remarks.—This species differs from *Nodosaria obscura* Reuss in being about one-half as large, in having less highly raised costae and in lacking the long produced neck of that species. It differs from *Nodosaria graysonensis* Tappan in having fewer costae, and in these being straight, without the bifurcation as present in *Nodosaria graysonensis*, and in being of greater diameter.

NODOSARIA RIGENTIA Loeblich and Tappan, n. sp.
Plate 49, figure 16

Test free, small, rectilinear; composed of a series of slightly inflated chambers, which are broader than high, increasing gradually in size from the tapering initial end, sutures distinct, constricted, straight; wall calcareous, finely perforate, surface smooth; aperture terminal, rounded.

Length of holotype 0.35 mm., greatest breadth of chambers 0.09 mm. Other specimens vary in length from 0.32 mm. to 0.48 mm., and in breadth from 0.09 to 0.12 mm.

Types and occurrence.—Holotype (USNM No. 104483), and unfigured paratypes (USNM No. 104484 and H. N. Loeblich Coll. 1130) from the Walnut clay, at locality HTL-74, Love County, Oklahoma. Unfigured paratypes (H. N. Loeblich Coll. 1131) also from the Walnut clay at locality HTL-105, Grayson County, Texas.

Remarks.—This species is somewhat similar to *Nodosaria lepida* Reuss, but differs in being about one-half as large, in having more inflated chambers, a more tapering base, and in the chambers increasing more regularly in size as added.

NODOSARIA sp.
Plate 49, figure 13

Test free, elongate, rectilinear, consisting of four subequal chambers, which increase very little in size as added, chambers slightly higher than broad, somewhat inflated; sutures distinct, constricted; wall calcareous, finely perforate, surface smooth; aperture terminal, simple.

Length of figured specimen 0.39 mm., greatest breadth 0.08 mm.

Types and occurrence.—Figured specimen (USNM No. 104485) from the Walnut clay at locality HTL-74, Love County, Oklahoma.

Genus PSEUDOGLANDULINA Cushman, 1929
PSEUDOGLANDULINA cf. MUTABILIS (Reuss)
Plate 49, figures 9–10

Glandulina mutabilis REUSS, 1863, Akad. Wiss. Wien., Sitz., vol. 46, p. 58, pl. 5, figs. 7–11.
Glandulina mutabilis Reuss, BERTHELIN, 1880, Soc. Geol. France, Mém. 5, p. 45.
Pseudoglandulina cf. *mutabilis* (Reuss), TAPPAN, 1940, Jour. Paleontology, vol. 14, no. 2, p. 105, pl. 16, figs. 15a–b.

Test free, small, short, stout; chambers increasing rapidly in size from the tapered base, so that the final chamber comprises about one-third to one-half the total length of the test, early chambers broad and low; sutures distinct, straight; wall calcareous, finely perforate, surface smooth; aperture terminal, simple.

Length varies from 0.23 mm. to 0.32 mm., breadth from 0.12 mm. to 0.18 mm.

Types and occurrence.—Figured hypotypes (USNM No. 104486), and unfigured hypotypes (USNM No. 104487 and H. N. Loeblich Coll. 1132) from the Walnut clay at locality HTL-74, Love County, Oklahoma.

Genus LINGULINA d'Orbigny, 1826
LINGULINA FURCILLATA Berthelin
Plate 49, figures 11–12

Lingulina furcillata BERTHELIN, 1880, Soc. Geol. France, Mém., ser. 3, vol. 1, no. 5, p. 65, pl. 4(27), figs. 6a–c.
Lingulina furcillata Berthelin, TAPPAN, 1940, Jour. Paleontology, vol. 14, no. 2, p. 106, pl. 16, figs. 18a–c.
Lingulina furcillata Berthelin, TAPPAN, 1943, Jour. Paleontology, vol. 17, no. 5, p. 499, pl. 80, figs. 11a–b.
Lingulina furcillata Berthelin, LOZO, 1944, Amer. Midland Nat., vol. 31, no. 3, p. 557, pl. 4, fig. 14.

Test free, small, flattened, elongate; chambers numerous, increasing rapidly in size at first, then more gradually, chambers flattened centrally, arched along the median line; sutures distinct, depressed, arched; wall calcareous, finely perforate, surface smooth; aperture terminal, elongate.

Length varies from 0.30 mm. to 0.55 mm., breadth from 0.12 to 0.16 mm., thickness from 0.07 to 0.09 mm.

Types and occurrence.—Figured hypotypes (USNM Nos. 104488a and b), and unfigured hypotypes (USNM No. 104489 and H. N. Loeblich Coll. 1133) all from the Walnut clay at locality HTL-74, Love County, Oklahoma.

Unfigured hypotypes (USNM No. 104519 and H. N. Loeblich Coll. 1134) from the Walnut clay at locality HTL-105, Grayson County, Texas.

Genus CITHARINA d'Orbigny, 1839

Genotype: Here designated *Citharina strigillata* Reuss, 1846, p. 106, pl. XXIV, fig. 29.

The genus *Citharina* was described by d'Orbigny (1839, p. XXXVII) but no species was named in the original publication. Marie (1938, p. 93) designated *Vaginulina striatula* Roemer, 1842, as genotype of *Citharina*, but under the Rules of International Zoological Nomenclature this designation is in error because *V. striatula* was not published in connection with *Citharina* (See Opinion 46 of the International Zoological Commission). The first species published in connection with the genus must become the type and *Citharina strigillata* Reuss, 1846, was the first species so referred.

CITHARINA INTUMESCENS (Reuss)
Plate 49, figure 15

Vaginulina intumescens REUSS, 1862 (1863), Akad. Wiss. Wien. Sitz., vol. 46, p. 49, pl. 4, fig. 2.
Vaginulina intumescens Reuss, CUSHMAN and ALEXANDER, 1930, Contr. Cushman Lab. Foram. Res., vol. 6, pt. 1, p. 5, pl. 2, figs. 1–6.
Vaginulina intumescens Reuss, LOZO, 1944, Amer. Midland Nat., vol. 31, no. 3, p. 559, pl. 4, fig. 10.

Test large, free, flattened, subtriangular in outline; chambers numerous, each extending ventrally nearly to the base; sutures distinct, thickened; wall calcareous, finely perforate, surface ornamentation varying from almost none to quite numerous longitudinal costae, which may continue across the sutures, or in some cases appear only at the sutures; aperture radiate at the dorsal angle.

Length of figured hypotype 1.20, greatest breadth 0.39 mm., greatest thickness 0.12 mm. Other hypotypes vary in length from 0.37 mm. (juvenile specimen) to 1.31 mm.

Types and occurrence.—Figured hypotype (USNM No. 104490) and unfigured hypotypes (USNM No. 104491 and H. N. Loeblich Coll. 1135) all from the Walnut clay at locality HTL-74, Love County, Oklahoma.

Genus QUADRATINA ten Dam, 1946
QUADRATINA EUTHEMON Loeblich and Tappan, n. sp.
Plate 49, figures 14a–b

Test free, small, elongate, subquadrate in section, rectilinear; chambers numerous, increasing gradually in size from the tapered initial end, last chamber higher than earlier ones, extending back almost one-third the length of the test, chambers subquadrate, extending backward toward the proloculum on each of the angles; sutures distinct, slightly depressed, arched slightly on the flat sides of the test, curving down at the angles; wall calcareous, finely perforate, surface smooth; aperture terminal, rounded.

Length of holotype 0.40 mm., greatest breadth 0.13 mm.

Types and occurrence.—Holotype (USNM Coll. 104492) and unfigured paratype (H. N. Loeblich Coll. 1136) both from the Walnut clay at locality HTL-74, Love County, Oklahoma.

Remarks.—This species differs from *Quadratina quadrata* (Vieaux) in being considerably smaller, in having rounded rather than excavated faces, and in having less distinct angles.

Family POLYMORPHINIDAE
Subfamily POLYMORPHININAE
Genus GUTTULINA d'Orbigny, 1839
GUTTULINA SYMPLOCA Loeblich and Tappan, n. sp.
Plate 50, figures 1a–2b

Test free, small, fusiform in outline; chambers arranged in a quinqueloculine series, with a considerable degree of overlap; sutures distinct, depressed; wall calcareous, surface smooth; aperture terminal, radiate.

Length of holotype 0.35 mm., greatest breadth 0.14 mm., greatest thickness 0.12 mm. Other specimens vary in length from 0.25 mm. to 0.46 mm.

Types and occurrence.—Holotype (USNM No. 104493) and figured paratype (USNM No. 104494) and unfigured paratypes (USNM No. 104495 and H. N. Loeblich Coll. 1138), all from the Walnut clay at locality HTL-74, Love County, Oklahoma.

Remarks.—This species is somewhat similar to *Guttulina woodsi* Cushman and Ozawa, but differs in having slightly more inflated chambers and a narrower test with less pointed extremities.

GUTTULINA sp.
Plate 50, figures 4a–c

Test free, small, flattened, fusiform in outline; chambers arranged in a quinqueloculine series, as can be seen from the base, although from a single side the test seems almost biserial; sutures distinct, depressed; wall calcareous, surface smooth; aperture terminal, radiate.

Length 0.35 mm., greatest breadth 0.14 mm., greatest thickness 0.08 mm.

Types and occurrence.—Figured specimen (USNM No. 104496) from the Walnut clay, at locality HTL-74, Love County, Oklahoma. This species is quite rare, only a single specimen having been seen.

Genus PSEUDOPOLYMORPHINA
Cushman and Ozawa, 1928
PSEUDOPOLYMORPHINA PLECTILIS Loeblich and Tappan, n. sp.
Plate 50, figures 3a–b

Test free, small, stout, subovate in outline; chambers at first arranged in a quinqueloculine series, later biserial, and extending far back over the preceding chambers; sutures distinct, slightly depressed; wall calcareous, surface smooth; aperture terminal, radiate.

Length of holotype 0.39 mm., greatest breadth 0.23 mm., greatest thickness 0.16 mm. Other specimens vary in length from 0.37 to 0.44 mm.

Types and occurrence.—Holotype (USNM No. 104497) and unfigured paratypes (USNM No. 104498 and H. N. Loeblich Coll. 1137) all from the Walnut clay at locality HTL-74, Love County, Oklahoma.

Remarks.—This species is similar to *Pseudopolymorphina mendezensis* (White) in the considerable amount of overlap of the chambers, but differs in being about one-

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EXPLANATION OF PLATE 50

Polymorphinidae

FIGS. *1a–2b—Guttulina symploca* Loeblich and Tappan, n. sp. *1a*, Side view of holotype (USNM 104493); *1b*, opposite side of holotype; *2a*, side view of paratype (USNM 104494); *2b*, opposite side of paratype; ×95. (p. 260)

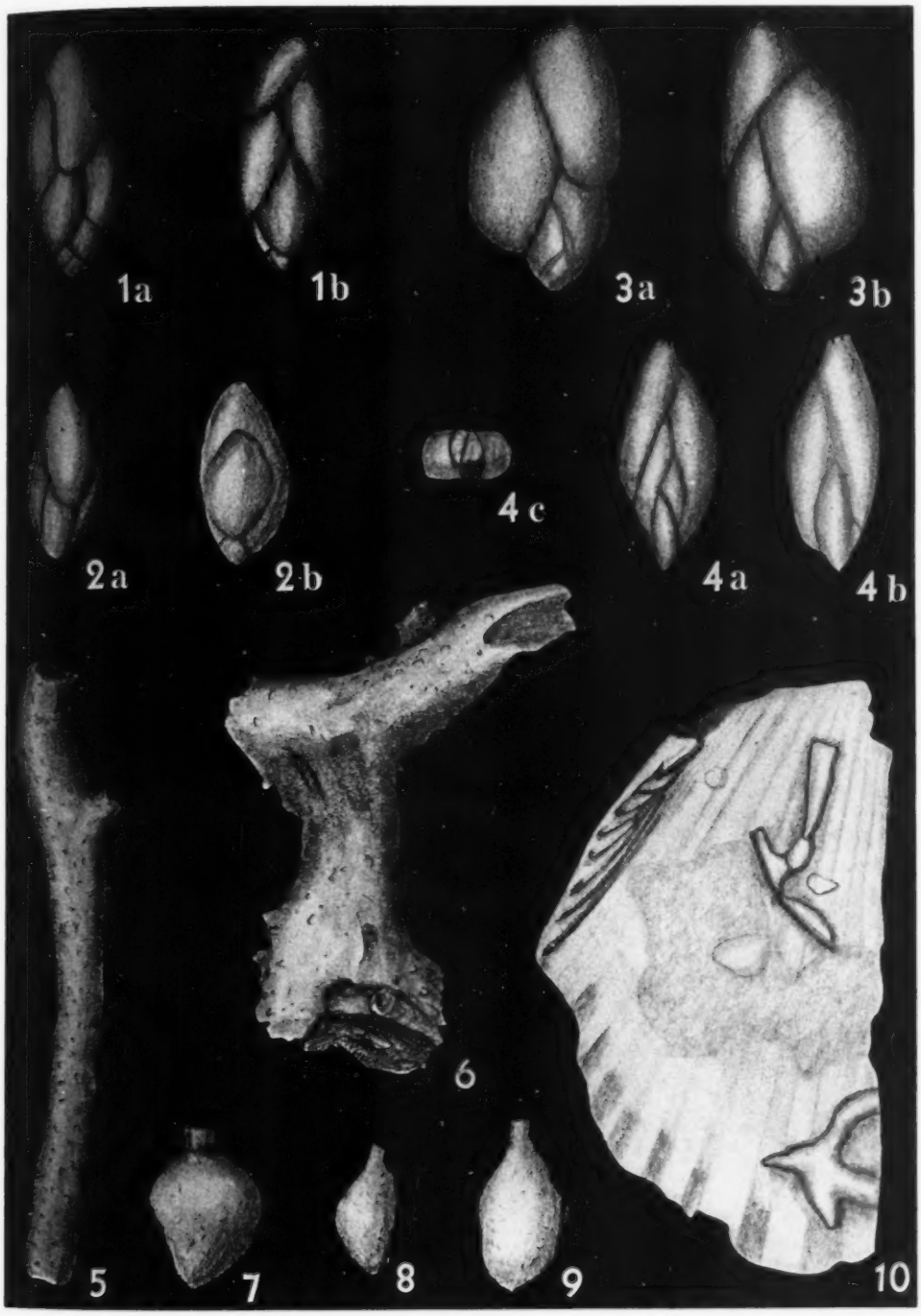
3a–b—Pseudopolymorphina plectilis Loeblich and Tappan, n. sp. *3a*, Side view of holotype (USNM 104497) showing great overlap of final pair of chambers; *3b*, opposite side of holotype; ×95. (p. 260)

4a–c—Guttulina sp. *4a*, Side view of figured specimen (USNM 104496); *4b*, opposite side of figured specimen; *4c*, basal view; ×95. (p. 260)

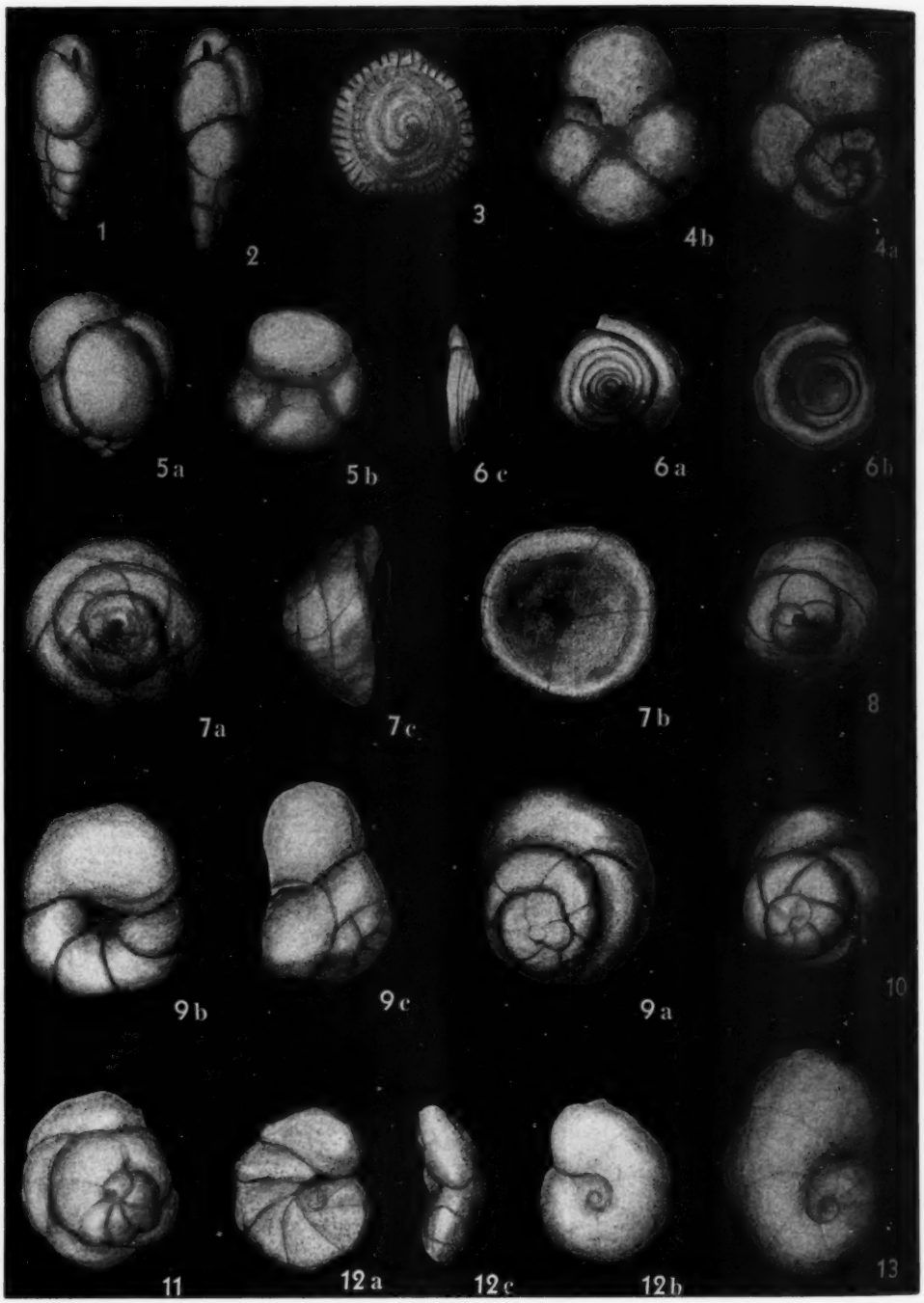
5–6—Ramulina muricatina Loeblich and Tappan, n. sp. *5*, View of paratype (USNM 104499a) showing finely hispid surface and tubular branches; *6*, view of paratype (USNM 104499b) showing more rapid branching and variation in diameter; ×72. (p. 261)

7–9—Ramulina sp. Side views of single chambers (USNM 104500); ×72. (p. 262)

10—Histopomphus cervicornis (Chapman). View of two specimens (USNM 104501) attached to a fragment of a *Pecten;* ×15. (p. 263)



Loeblich and Tappan, Walnut clay Foraminifera



Loeblich and Tappan, Walnut clay Foraminifera

half as large, and in having a more acute initial end, composed of much smaller early chambers.

Subfamily RAMULININAE
Genus RAMULINA Rupert Jones, 1875
RAMULINA MURICATINA Loeblich and Tappan, n. sp.
Plate 50, figures 5, 6

Ramulina aculeata Wright, CHAPMAN, 1896 (part) (not *Dentalina aculeata* d'Orbigny 1840; not *Ramulina aculeata* d'Orbigny, Wright, 1886), Jour. Roy. Micr. Soc., p. 583, pl. XII, figs. 8, 9 (not figure 7).
Ramulina aculeata Wright, EICHENBERG, 1933, Niedersächs geol. Vereins zu Hanover, Jahresber. 25, Teil 1, Folge 1, pl. 18, p. 6, fig. 6b (not fig. 6a).
Ramulina aculeata Wright, TAPPAN, 1943, Jour. Paleontology, vol. 17, no. 5, p. 506, pl. 81, fig. 7 (not fig. 6).
Ramulina aculeata Wright, BROTZEN, 1936, Sveriges Geol. Undersökning, ser. C., no. 396, Arsbok 30, no. 3, p. 116, text fig. 38.
Ramulina aculeata Wright, MARIE, 1941, Mém. du Mus. Nat. d'Histoire Naturelle, n. ser., tome 12, fasc. 1, p. 178, pl. 27, figs. 261–264.

Test free, composed of elongate, irregular, cylindrical branches, represented only by fragments because of the fragile character; wall calcareous, perforate, surface covered with fine spines; aperture at the open ends of the tubes.

Length of holotype from the Duck Creek formation (See Tappan, 1943, pl. 81, fig. 7) 1.4 mm., greatest breadth 0.29 mm. Length of paratype from the Walnut (fig. 5) 1.17 mm., greatest breadth 0.12 mm.; length of paratype of fig. 6, 1.01 mm., greatest breadth of cylindrical portion 0.21 mm.

Types and occurrence.—Holotype (Cushman Coll.) from the Duck Creek formation, Washita group, from the west bank of the Red River, in the SW¼, Sec. 22, T. 8 S., R. 2 E., on the southwest side of Horseshoe Bend, Love County, Oklahoma. Figured paratypes (USNM Nos. 104499a and b) and unfigured paratypes (H. N. Loeblich Coll. 1139) from the Walnut clay at locality HTL-74, Love County, Oklahoma.

Remarks.—This species differs from *Ramulina laevis* Jones in having more regular cylindrical branches and in having a hispid surface. D'Orbigny (1840, p. 13, pl. 1, figs. 2–3) described and figured an arcuate, hispid foraminifer under the name *Dentalina aculeata*. Later Wright (1886, p. 331, pl. 27, fig. 11) listed and figured a foraminifer referring it to d'Orbigny's species, but assigning it to the genus *Ramulina*. The figured specimens of d'Orbigny and Wright agree closely in form, outline, ornamentation and size. Since the date of Wright's paper, subsequent

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EXPLANATION OF PLATE 51

Buliminidae to Globigerinidae

FIGS. *1–2—Neobulimina minima* Tappan. *1*, Side view of hypotype (USNM 104504a); *2*, side view of hypotype (USNM 104504b); ×145. (p. 263)
3—Patellina subcretacea Cushman and Alexander. Dorsal view of hypotype (USNM 104508) showing obscure sutures and scale-like form; ×105. (p. 264)
4a–b—Globigerina washitensis Carsey. *4a*, Dorsal view of hypotype (USNM 104518) showing small form with faintly reticulated surface; *4b*, ventral view of hypotype showing aperture; ×145. (p. 265)
5a–b—Bulimina evexa Loeblich and Tappan, n. sp. *5a*, Side view of holotype (USNM 104502) showing extremely inflated chambers and rapid increase in breadth of test; *5b*, top view showing spiral character of test; ×145. (p. 263)
6a–c—Turrispirillina subconica Tappan, *6a*, Dorsal view of hypotype (USNM 104506) showing convex surface; *6b*, ventral view showing concave underside; *6c*, edge view showing low conical form; ×105. (p. 264)
7a–8—Conorbina conica Lozo. *7a*, Dorsal view of hypotype (USNM 104509a); *7b*, ventral view of hypotype; *7c*, edge view of hypotype; *8*, dorsal view of hypotype (USNM 104509b); ×63. (p. 264)
9a–11—Discorbis floscula Loeblich and Tappan, n. sp. *9a*, Dorsal view of holotype (USNM 104511) showing inflated central portion and rapid increase in size of later chambers; *9b*, ventral view of holotype showing large final chamber and deep umbilicus; *9c*, edge view of holotype showing high spired nature of test; *10*, dorsal view of paratype (USNM 104512); *11*, dorsal view of paratype (USNM 104514); ×105. (p. 265)
12a–13—Discorbis cf. *D. minima* Vieaux. *12a*, Ventral view of hypotype (USNM 104516a); *12b*, dorsal view of hypotype; *12c*, edge view of hypotype; *13*, dorsal view of hypotype (USNM 104516b); ×63. (p. 265)

workers have assigned a variety of forms to the combinations *Ramulina aculeata* and *Dentalina aculeata* citing d'Orbigny and Wright interchangeably as the author of the species. Because the original species *Dentalina aculeata* seems definitely to belong to *Dentalina*, the combination *Ramulina aculeata* is in error, as in no publication was a new species of *Ramulina* described with the specific name *aculeata*, the references always citing either d'Orbigny or Wright as author. Thus the "*Ramulina*" must have a new name.

Two distinct types of Foraminifera have been referred to *Ramulina aculeata*, one consisting of subglobular chambers (part of Chapman, Eichenberg, and Tappan), the other composed of irregular, cylindrical branches, which is the form present in the Walnut (see synonomy above) and which is here described as new.

RAMULINA sp.
Plate 50, figures 7–9

Test free, composed of subpyriform to subovate chambers, probably originally connected by thin and fragile necks, although no specimens of more than one chamber have been observed, occasional chambers seem to show evidence of a "neck" at both ends; necks short and cylindrical; wall calcareous, finely perforate, surface smooth; aperture rounded, at the end of the neck.

Length of chambers varies from 0.23 to 0.32 mm., greatest breadth from 0.12 to 0.23 mm.

Types and occurrence.—Figured specimens (USNM No. 104500) and unfigured specimens (H. N. Loeblich Coll. 1140) from the Walnut clay, at locality HTL-74, Love County, Oklahoma.

Genus HISTOPOMPHUS Loeblich and Tappan, new genus

Genotype: *Globulina redriverensis* Tappan, 1943.

Polymorphina (part) of Chapman, 1892 (not d'Orbigny, 1826).
Ramulina (part) of Chapman, 1896 (not Rupert Jones, 1875).
Vitriwebbina (part) of Eichenberg, 1934 (not Chapman, 1892)
Bullopora (part) of Tappan, 1940, 1943, Lozo, 1944 (not Quenstedt, 1856).
Globulina (part) of Tappan, 1943, (not d'Orbigny, 1839).

The name is derived from *histos* Gr., web + *pomphos* Gr., blister.

Test large, early portion free and polymorphine in character, later portion attached, somewhat tubular in character, frequently branching or bifurcating; wall calcareous, perforate; aperture a low arch at the ends of the tubular growths, or rounded.

Remarks.—A restudy of the genotype species of *Bullopora* by Macfadyen (1941, p. 25) showed that it is an imperforate form belonging to the *Ophthalmidiidae*. The genus *Vitriwebbina* of Chapman is thus resurrected for some of the forms referred to *Bullopora*, which are calcareous and perforate. The genotype is *Vitriwebbina sollasi* Chapman (designated by Cushman, 1927, p. 189). This species consists of attached bulbous chambers, rather than a branching tubular attached form and does not have a many-chambered polymorphine initial portion. This leaves the tubular forms without a generic name, hence they are here described as new.

The genotype of *Histopomphus* (*Globulina redriverensis*) was described by Tappan (1943, p. 505) with the notation that "Attached species of the Polymorphininae are extremely rare, probably less than half a dozen having been recorded to date. The attached area of *Globulina redriverensis* is elongate and quite conspicuous, and thus differs from that of the earlier described attached species, all of which have only an ovate, flattened area of small size surrounding the earlier portion of the test."

Because the polymorphine early portion stands up somewhat above the level of the attached portion, it is frequently broken off and many specimens from which it was broken have been referred to *Bullopora* or *Vitriwebbina*. Diligent search will generally show a few complete specimens however. Lozo (1944, p. 559) described as a new species, *Bullopora irregularis*, and noted in the plate description of the holotype that it was "partially obscured by a cemented polymorphinid on the central bulb." Study of a large series of specimens has shown that this "cemented polymorphinid" is in reality the early stage of the species which later became attached and branching, and Lozo's species is the same as the present genotype species, *Histopomphus redriverensis*.

In addition to the genotype, the species

originally described as *Polymorphina orbignyi* var. *cervicornis* Chapman also belongs here. This species has later been referred to *Ramulina*, *Vitriwebbina* and *Bullopora*. Chapman did not consider it to be the same as his genus *Vitriwebbina* for the original definition of *Vitriwebbina* was in the same publication as his original description of *Polymorphina orbignyi* var. *cervicornis*, and later he referred the latter species to *Ramulina*, from which it differs in the attached character.

HISTOPOMPHUS CERVICORNIS (Chapman)
Plate 50, figure 10

Polymorphina orbignyii Zborzewski var. *cervicornis* CHAPMAN, 1892, Geol. Mag., n. ser., dec. 3, vol. 9, p. 54, pl. 2, figs. 5–6.
Ramulina cervicornis (CHAPMAN), 1896, Royal Micr. Soc., Jour., p. 584, pl. 12, figs. 10, 11.
Vitriwebbina cervicornis (Chapman), EICHENBERG, 1934, Niedersachs. geol. Vereins zu Hannover Jahresb. 26, p. 184, pl. 16, fig. 2.
Bullopora cervicornis (Chapman) TAPPAN, 1940, Jour. Paleontology, vol. 14, no. 2, p. 114, pl. 18, fig. 5; 1943, Jour. Paleontology, vol. 17, no. 5, p. 506, pl. 81, fig. 10.

Test large, consisting of a polymorphine early portion, later developing an elongate branching, attached tube, with the bifurcation generally dichotomous; wall calcareous, perforate, surface smooth; apertures at the open ends of the tubes.

The branching attached portion attains a length up to nearly 2 mm.

Types and occurrence.—Hypotype (USNM No. 104501) from the Walnut clay at locality HTL-74, Love County, Oklahoma.

Remarks.—Chapman's original description stated "The test . . . commences with a polymorphine arrangement of chambers, which proceeds to take on a wild flattened fistulose growth, sometimes six times the length of the initial series of chambers. The apertures are simple orifices at the terminations of the branchlets."

This species differs from *H. redriverensis* (Tappan) in possessing a stouter polymorphine portion, and a more rapidly branching attached portion. The tubular attached portion of *H. redriverensis* is more elongate and slender, and does not show the frequent bifurcation of Chapman's species.

Family BULIMINIDAE
Subfamily BULIMININAE
Genus BULIMINA d'Orbigny, 1826
BULIMINA EVEXA Loeblich and Tappan, n. sp.
Plate 51, figures 5a–b

Bulimina nannina TAPPAN, 1943 (not Tappan 1940), Jour. Paleontology, vol. 17, no. 5, p. 507, pl. 81, fig. 15.

Test free, tiny, stout, triserial; chambers moderately inflated, increasing rapidly in size from the apical portion, the last chamber comprising half the length of the test; sutures distinct, depressed; wall calcareous, finely perforate, surface smooth; aperture an arch at the base of the apertural face of the final chamber.

Length of holotype 0.16 mm., greatest breadth 0.14 mm.; other specimens from 0.14 mm. to 0.17 mm. in length.

Types and occurrence.—Holotype (USNM No. 104502), unfigured paratypes (USNM No. 104503 and H. N. Loeblich Coll. 1141) all from the Walnut clay, at locality HTL-74, Love County, Oklahoma. The species also occurs in the Duck Creek formation (Washita group).

Remarks.—This species differs from *Bulimina nannina* Tappan in being smaller and more twisted. In *Bulimina nannina* the triserially arranged chambers form three definite vertical rows, while in *B. evexa* the test appears somewhat twisted. The chambers of the present species are more inflated and increase more rapidly in size, so that the base is less tapering.

Genus NEOBULIMINA Cushman and Wickenden, 1928
NEOBULIMINA MINIMA Tappan
Plate 51, figures 1–2

Neobulimina minima TAPPAN, 1940, Jour. Paleontology, vol. 14, no. 2, p. 117, pl. 19, figs. 5a–b; 1943, Jour. Paleontology, vol. 17, no. 5, p. 507, pl. 81, figs. 16a–b.

Test free, tiny, tapering, rounded in cross-section, early portion triserial, later biserial; chambers twisted somewhat about the axis of the test, inflated, increasing gradually in size, until the final series, which is much higher, the last chambers comprising about one-third the length of the test; wall calcareous, surface smooth; aperture a loop at the base of the last-formed chamber.

Length of hypotypes from the Walnut varies from 0.14 to 0.23 mm.

Types and occurrence.—Figured hypotypes (USNM No. 104504a and b) and unfigured hypotypes (USNM No. 104505 and H. N. Loeblich Coll. 1142) all from the Walnut clay at locality HTL-74, Love County, Oklahoma. The species occurs throughout the Washita group.

Family SPIRILLINIDAE
Subfamily TURRISPIRILLININAE
Genus TURRISPIRILLINA Cushman, 1927
TURRISPIRILLINA SUBCONICA Tappan
Plate 51, figures 6a–c

Turrispirillina subconica TAPPAN, 1943, Jour. Paleontology, vol. 17, no. 5, p. 510, pl. 82, figs. 2a–3.

Test small, conical, consisting of a small rounded proloculum, followed by an elongate tubular coiled second chamber, which forms a low, hollow, conical spire, coils evolute, usually five to six volutions; spiral suture distinct; wall calcareous, surface smooth; aperture formed by the open end of the tubular chamber.

Greatest diameter of hypotype 0.17 mm., least diameter 0.16 mm., height of spire 0.05 mm.

Types and occurrence.—Figured hypotype (USNM No. 104506) and unfigured hypotypes (USNM No. 104507 and H. N. Loeblich Coll. 1143) all from the Walnut clay at locality HTL-74, Love County, Oklahoma. The species was originally described from the Duck Creek formation (Washita group).

Subfamily PATELLININAE
Genus PATELLINA Williamson, 1858
PATELLINA SUBCRETACEA Cushman and Alexander
Plate 51, figure 3

Patellina subcretacea CUSHMAN and ALEXANDER, 1930, Contr. Cushman Lab. Foram. Res., vol. 6, pt. 1, p. 10, pl. 3, figs. 1a, b.
Patellina subcretacea Cushman and Alexander, TAPPAN, 1943, Jour. Paleontology, vol. 17, no. 5, p. 511, pl. 82, figs. 4a–b.
Patellina subcretacea Cushman and Alexander, Lozo, 1944, Amer. Midland Nat., vol. 31, no. 3, p. 561, pl. 4, fig. 8.

Test free, small, scale-like, conical, ventral side concave, dorsal side convex; early portion consisting of an elongate spiral undivided tubular chamber of several coils, later chambers narrow and elongate, two to each whorl; sutures not distinct; wall calcareous, thin, translucent, surface smooth; aperture at the base of the ventral side of the chamber.

Greatest diameter of figured hypotype 0.21 mm., other hypotypes from the Walnut vary from 0.18 mm. to 0.30 mm.

Types and occurrence.—Figured hypotype (USNM No. 104508—and unfigured hypotypes (H. N. Loeblich Coll. 1144), from the Walnut clay at locality HTL-74, Love County, Oklahoma.

Remarks.—Lozo (1944, p. 561) stated that Vanderpool apparently confused the form described as *Conorbina conica* with the true *Patellina subcretacea* and that he found only the former from Vanderpool's locality. The writers find typical *Patellina subcretacea* to be present in these beds, but much rarer than *Conorbina conica*.

Family ROTALIIDAE
Subfamily DISCORBINAE
Genus CONORBINA Brotzen, 1936
CONORBINA CONICA Lozo
Plate 51, figures 7a–8

Conorbina conica Lozo, 1944, Amer. Midland Nat., vol. 31, no. 3, p. 562, pl. 2, figs. 6a–c, 7.

Test free, small, conical, dorsal side convex, ventral side concave, rounded in outline; chambers numerous, the four to five of the last whorl being visible ventrally, all chambers of the two to three whorls visible dorsally, chambers somewhat inflated, the outside wall of those of the central coil frequently broken out, giving a characteristic appearance to the test; sutures slightly depressed, strongly curved backwards at the periphery on the dorsal side, nearly straight on the ventral side; wall calcareous, surface smooth; aperture a narrow slit on the ventral side.

Greatest diameter of hypotypes from the Walnut varies from 0.30 mm. to 0.48 mm., height from 0.14 to 0.18 mm.

Types and occurrence.—Figured hypotypes (USNM No. 104509a and b) and unfigured hypotypes (USNM No. 104510 and H. N. Loeblich Coll. 1145) all from the Walnut clay at locality HTL-74, Love County, Oklahoma.

Genus DISCORBIS Lamarck, 1804
DISCORBIS FLOSCULA Loeblich and Tappan, n. sp.
Plate 51, figures 9a–11

Test free, tiny, high-spired dorsally, ventrally umbilicate, all chambers visible dorsally, only those of the last whorl visible ventrally; chambers much inflated, about five chambers in the last whorl increasing rapidly in size, the last chamber occupying three-fifths of the periphery, 2½ whorls usually present; sutures distinct, depressed, sharply curved backwards on the periphery dorsally; wall calcareous, surface smooth; aperture at the base of the last chamber, slightly ventral from the periphery.

Greatest diameter of holotype 0.25 mm., least diameter 0.21 mm., height 0.18 mm. Other specimens vary from 0.16 mm. to 0.28 mm. in diameter.

Types and occurrence.—Holotype (USNM No. 104511), figured paratype (USNM No. 104512), and unfigured paratypes (USNM No. 104513 and H. N. Loeblich Coll. 1146) all from the upper Goodland, in a low bluff on the east bank of the North Fork of Mary's Creek, at the concrete bridge on the Fort Worth-Weatherford highway, 11½ miles west of Fort Worth, Tarrant County, Texas. Figured paratype (USNM No. 104514) and unfigured paratypes (USNM No. 104515 and H. N. Loeblich Coll. 1147), all from the Walnut clay, at locality HTL-74, Love County, Oklahoma.

Remarks.—This species is similar to *Discorbis scanica* Brotzen in size, in the high spire, and extremely large last chamber, but differs in having more chambers in the last whorl, a less extensive final chamber, and more gradual increase in height of the whorls.

DISCORBIS cf. D. MINIMA Vieaux
Plate 51, figures 12a–13

Discorbis minima VIEAUX, 1941, Jour. Paleontology, vol. 15, no. 6, p. 627, pl. 85, figs. 10a–c.
Discorbis minima Vieaux, TAPPAN, 1943, Jour. Paleontology, vol. 17, no. 5, p. 511, pl. 82, figs. 7a–8b.

Test free, small, trochoid, flattened and somewhat umbilicate ventrally, whorls slightly overlapping dorsally, about seven chambers in the last volution; sutures somewhat obscure, convex toward the aperture, curving backward at the periphery; wall calcareous, surface smooth; aperture at the base of the last-formed chamber. Specimens vary in diameter from 0.25 to 0.48 mm.

Types and occurrence.—Figured hypotypes (USNM No. 104516) and unfigured hypotypes (USNM No. 104517 and H. N. Loeblich Coll. 1148), all from the Walnut clay at locality HTL-74, Love County, Oklahoma.

Remarks.—This is the species figured by Vanderpool as *Planulina* sp., but appears to be more closely related to *Discorbis*.

Family GLOBIGERINIDAE
Subfamily GLOBIGERININAE
GLOBIGERINA WASHITENSIS Carsey
Plate 51, figures 4a–b

Globigerina sp. CARPENTER, 1925, Univ. Texas Bull. 2544, pl. 17, fig. 5.
Globigerina washitensis CARSEY, 1926, Univ. Texas Bull. 2612, p. 44, pl. 7, fig. 10, pl. 8, fig. 2.
Globigerina washitensis Carsey, PLUMMER, 1931, Univ. Texas Bull. 3101, p. 193, pl. 13, fig. 12.
Globigerina washitensis Carsey, TAPPAN, 1940, Jour. Paleontology, vol. 14, no. 2, p. 122, pl. 19, figs. 13a–c; 1943, Jour. Paleontology, vol. 17, no. 5, p. 513, pl. 83, figs. 1a–2.
Globigerina washitensis Carsey, LOZO, 1944, Amer. Midland Nat., vol. 31, no. 3, p. 563, pl. 3, fig. 4.

Test free trochoid, composed of much inflated bulbous chambers which increase rapidly in size, four to five in the final volution; sutures constricted, distinct; wall calcareous, surface covered with coarse reticulations; aperture at the base of the last-formed chamber, opening into the deep ventral umbilicus.

Hypotypes from the Walnut are somewhat smaller than average for the species, being about 0.18 to 0.21 mm. in greatest diameter.

Types and occurrence.—Figured hypotype (USNM No. 104518) and unfigured hypotype (H. N. Loeblich Coll. 1149) both from the Walnut clay at locality HTL-74, Love County, Oklahoma.

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UPPER EOCENE LARGER FORAMINIFERA FROM THE PANAMA CANAL ZONE*

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ABSTRACT—Ten species of larger Foraminifera of upper Eocene age and a teratologic form of one of these species are discussed from a locality in the vicinity of Gatun Lake, Panama Canal Zone. This fauna is of great interest because of its geographic position and the association of species from the Gulf Coast of the United States with other species from the Caribbean region. A new specific name is proposed for the well-known species, *Lepidocyclina mortoni* Cushman, 1920, whose specific name is preoccupied by *Lepidocyclina mortoni* Prever, 1912.

In the description of larger Foraminifera from the Panama Canal Zone, Cushman (1919) assigned certain species to the Oligocene which are known now to be Eocene forms. These Eocene species were recorded from localities west of the Canal Zone near David, in Chiriqui Province, and in the Tonosi valley, Los Santos Province. Although other Foraminifera of late Eocene age have been recorded from localities in Panama east of the Canal Zone (Vaughan, 1926; Coryell and Embich, 1937), marine Eocene deposits were not definitely known to occur within the Canal Zone until the spring of 1947, at which time T. F. Thompson, Chief of the Geological Section of the Special Engineering Division, Panama Canal, recognized larger Foraminifera of Eocene age in float outcrop and core samples from a locality in the Gatun Lake area. This locality, near the eastern border of the Zone, is shown on the generalized geologic map (MacDonald, 1919) of the Zone as underlain by the Bohio formation, a nonmarine formation considered to be Oligocene in age. Mr. Thompson forwarded the samples to the United States Geological Survey and that agency submitted them to the writer.

Although the areal geology of the region in which these larger Foraminifera were collected has not been worked out in detail,† it seems appropriate to publish a record of these fossils, pending additional field work by the geological staff of The Panama Canal.

Two samples, both consisting of limestone, were received: one, a short section of core at a depth of 74 feet, from core hole SL-84, Gatun Lake area, 3.6 miles north-northwest of Frijoles, on the divide between Quebrada Juan Gallegos and Quebrada La Chinilla; and the other, outcrop float from the same locality. The float sample, collected near the collar of the core hole close to the summit of a low divide, presumably represents a higher horizon than the core sample.

Larger Foraminifera are extremely abundant in both of these samples, and of such size that they are readily visible to the unaided eye. It was possible to split the core in such a manner that matrix-free specimens could be secured, but the outcrop sample was too indurated for such treatment. From the outcrop sample 14 random thin sections were made, and six thin sections were cut from the core sample as a check against the specimens recovered by splitting portions of the core.

From the two samples ten species and a teratologic form of larger Foraminifera were identified. Certain species, as *Lepidocyclina* (*Lepidocyclina*) *montgomeriensis* Cole, nom. nov., are extremely abundant in both samples, whereas others, for example *Heli-*

* Published by permission of the Governor of The Panama Canal and the Director, United States Geological Survey.

† Since this was written, W. P. Woodring and T. F. Thompson have published on the occurrence of the Gatuncillo formation (Late Eocene) in the Canal Zone—Tertiary formations of the Panama Canal Zone and adjoining parts of Panama: Bull. Amer. Assoc. Petrol. Geol., vol. 33, no. 2, p. 228, 1949.

TABLE I.—DISTRIBUTION OF THE SPECIES

Species in the present collection	Other localities from which the species have been reported							
	Nicaragua	Trinidad	Curaçao	Jamaica	Cuba	Mexico	Venezuela	Southern U. S.
**Camerina striatoreticulata* (L. Rutten)		x	x	x	x			
**Operculinoides floridensis* (Heilprin)								x
* *ocalanus* (Cushman)		x				x		x
**Lepidocyclina* (*Lepidocyclina*) *montgomeriensis* Cole, nom. nov.		x			?			x
* (*Pliolepidina*) *macdonaldi* Cushman		x	x	x		x	x	x
pustulosa H. Douvillé		x	x	x	?	x	x	
forma *tobleri* H. Douvillé		x	x					
Helicolepidina spiralis Tobler		x	x		?	x	x	
†*Discocyclina* (*Discocyclina*) *minima* (Cushman)				?				
**Asterocyclina georgiana* (Cushman)	x			x	x		x	x
Pseudophragmina (*Proporocyclina*) *flintensis* (Cushman)	x				x			x

* Common to both samples.
† Found only in the outcrop sample.

colepidina spiralis Tobler, are very rare and appear to occur in only one of the samples.

Although no new species were found, the fauna is most interesting because of the large number of species and because of the occurrence of these species elsewhere. Table I lists the species found in the present collection and shows the distribution of these species at other important localities.

Of the species found in the present collection the following have been reported previously from Eocene localities in Panama (Cushman, 1919; Vaughan, 1926):

Operculinoides ocalanus (Cushman)
Lepidocyclina (*Pliolepidina*) *macdonaldi* Cushman
L. pustulosa forma *tobleri* H. Douvillé
Discocyclina (*Discocyclina*) *minima* (Cushman)
Asterocyclina georgiana (Cushman)

Vaughan (1926) reports the following species from the Eocene at San Juan de Pequeni, a locality in the Chagres valley now flooded by Madden Lake: *Operculina* sp. cf. *O. ocalana* Cushman, *Heterostegina ocalana* var. *glabra* Cushman, *Asteriacites georgiana* (Cushman), *Lepidocyclina* (*Nephrolepidina*) *chaperi* Lem. and R. Douvillé, *Lepidocyclina* sp. indet., and *Discocyclina* sp. The only species common to this fauna and the one under discussion are *Asterocyclina georgiana* and *Operculinoides ocalanus*.

All the material used in preparing this article is deposited in the United States National Museum. Drs. W. P. Woodring and Lloyd Henbest of the United States Geological Survey supplied helpful information, and appreciation is expressed for their courtesy.

Systematic descriptions

Family Camerinidae

Genus Camerina Brugière

Camerina striatoreticulata (L. Rutten)

Plate 52, figures 11–13; Plate 55, figure 7

Nummulites striatoreticulatus L. Rutten, 1928, Proc. Kon. Akad. van Wetensch., vol. 31, pp. 1068–1070, text figs. 41–50, pl. figs. F–J; Barker, 1938, Geol. Mag., vol. 75, pp. 49–51, pl. 3, figs. 1–5.

Camerina sp. Vaughan, 1929, Jour. Paleontology, vol. 3, p. 377, pl. 40, fig. 1.

Camerina petri M. G. Rutten, 1935, Jour. Paleontology, vol. 9, pp. 530–531, pl. 59, figs. 1–5, text fig. 2 (*not Nummulites petri* Mancini, 1928).

Camerina striatoreticulata Vaughan and Cole, 1941, Geol. Soc. America, Sp. Paper 30, pp. 31, 32, pl. 8, figs. 5–7.

This species has been reported previously from the upper Eocene of Curaçao, Jamaica, Trinidad, and Cuba. As adequate descriptions of this species have been given and as the illustrations show all the essential features, a detailed description of the Panamanian specimens is not necessary.

As Rutten noted in the type description "in the median plane the septa are simple, a little beyond the median plane they exhibit an anteriorly directed process." This process is a well-marked feature in all specimens that have been examined. It is well shown in figure 7, plate 55 made from one of the specimens in the present collection.

Certain measurements of these specimens follow:

Median sections

Specimen	1	2	3
Height	3.8 mm.	3.7 mm.	4.3 mm.
Width	3.6 mm.	3.7 mm.	4.24 mm.
Number of coils	6	6	6
Number of chambers in final volution	24	19	20
Internal diameter of initial chamber	100μ	110μ	160μ
Internal diameters of second chamber	90×180μ	90×160μ	80×200μ

Transverse sections

Specimen	1	2
Height	4.0 mm.	4.1 mm.
Thickness	1.36 mm.	1.6 mm.
Length of embryonic chambers	200μ	340μ
Height of embryonic chambers	160μ	280μ

Genus OPERCULINOIDES Hanzawa, 1935
OPERCULINOIDES FLORIDENSIS (Heilprin)
Plate 52, figure 3

Nummulites floridensis HEILPRIN, 1885, Proc. Nat. Acad. Sci., Philadelphia, pp. 321–322, text fig.
Operculina floridensis CUSHMAN, 1921, U. S. Geol. Survey Prof. Paper 128, p. 130, pl. 20, fig. 12.
Operculinoides floridensis COLE, 1941, Florida Geol. Survey Bull. 19, pp. 30–31, pl. 9, fig. 8; pl. 10, figs. 1–3; — 1944, *ibid.*, Bull. 26, pp. 43, 44, pl. 1, figs. 11, 13; pl. 5, figs. 7–9, 15, 18, 19.

Several specimens of *Operculinoides* were separated from the matrix of the core specimen and numerous random sections occur in the thin sections. The external sculpture of all the specimens recovered was so imperfect that the ornamentation could not be studied. At first it was believed that all these specimens represented one species. However, certain differences were apparent in the oriented thin sections.

The largest specimen of which a median section was made has a height of 3.1 mm. and a width of 2.6 mm. This specimen has approximately 34 chambers in the final volution. The initial chamber has an internal diameter of 80 μ and the second chamber has internal diameters of 40×100 μ.

The large number of chambers in the final volution, the shape of the chambers and the curvature of the chamber walls is identical with these features in the Floridian species described by Heilprin.

OPERCULINOIDES OCALANUS (Cushman)
Plate 52, figures 1, 2

Operculina ocalana CUSHMAN, 1921, U. S. Geol. Survey Prof. Paper 128, p. 129, pl. 19, figs. 4,5.
Operculinoides ocalanus COLE, 1941, Florida Geol. Survey Bull. 19, pp. 31, 32, pl. 10, figs. 4–7 (references); — 1944, *ibid.*, Bull. 26, pp. 48–49, pl. 1, figs. 5, 10; pl. 2, fig. 8; pl. 5, figs. 1, 4–6; pl. 7 figs. 18, 20.

The one available well-oriented median section was made from a specimen with a height of 2.6 mm. and a width of 2.0 mm. This specimen has $3\frac{1}{4}$ coils with 19 chambers in the final volution. The initial chamber has an internal diameter of 60 μ and the second chamber has internal diameters of 40×90 μ.

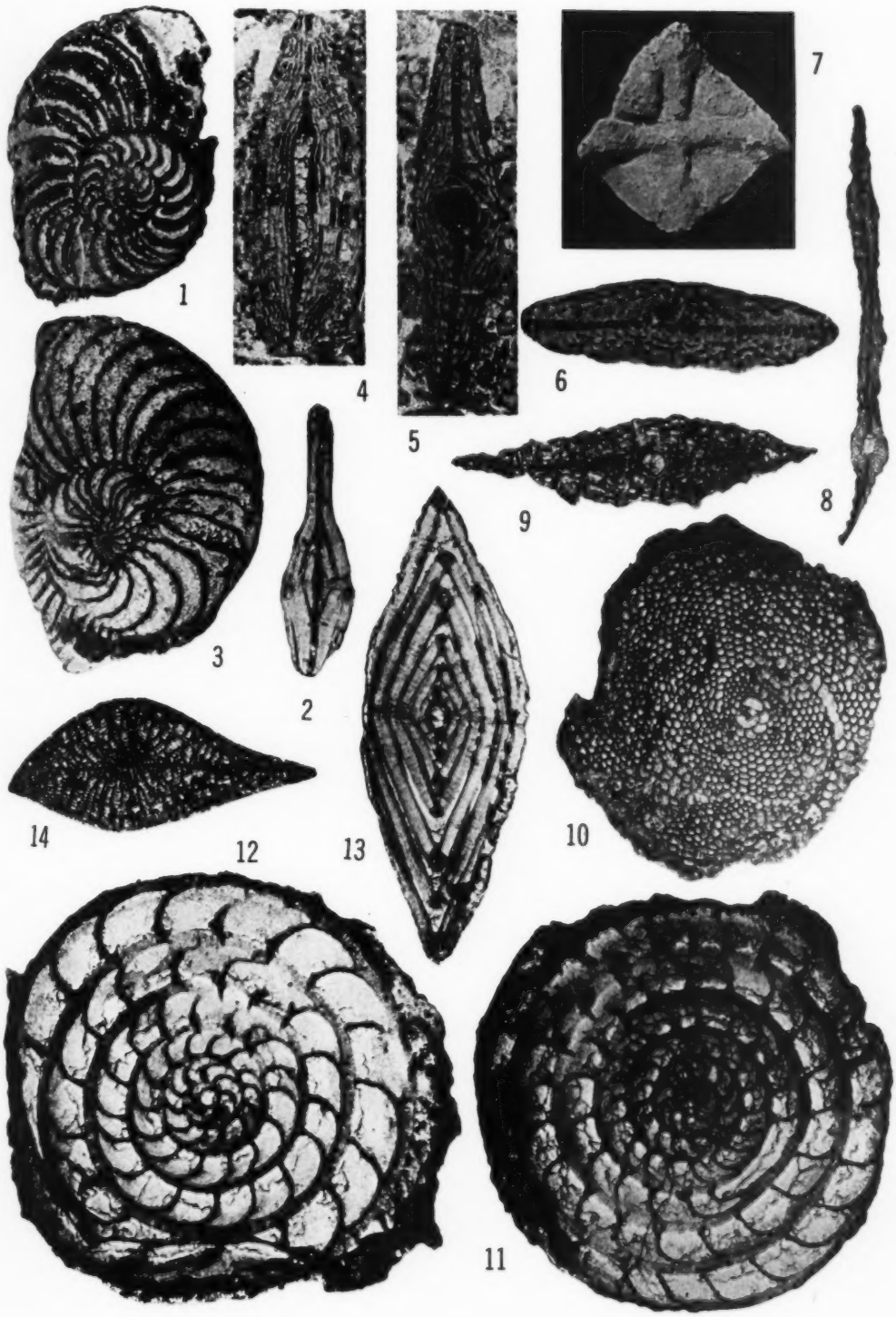
The transverse sections show that the thickness through the center of the test over the embryonic chambers is 0.5 to 0.7 mm. The flange has a thickness of 0.14 to 0.24 mm.

Family ORBITOIDIDAE Schubert
Genus LEPIDOCYCLINA Gümbel, 1870
Subgenus LEPIDOCYCLINA Gümbel, 1870
LEPIDOCYCLINA (LEPIDOCYCLINA) MONTGOMERIENSIS Cole, nom. nov.
Plate 53, figures 2–11; Plate 54, fig. 8

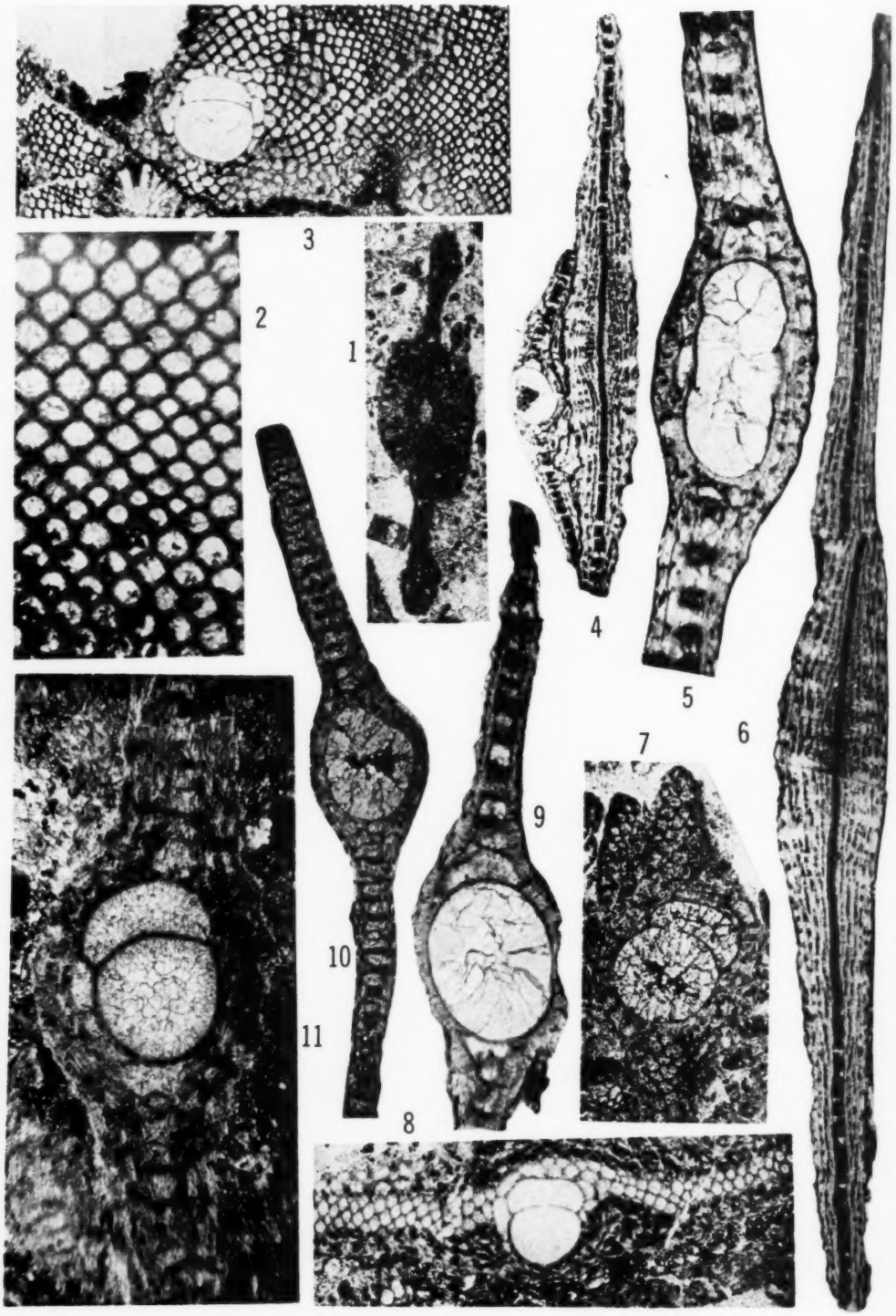
Lepidocyclina mortoni CUSHMAN, 1920, U. S. Geol. Survey Prof. Paper 125, pp. 70–71, pl. 27, figs. 1–4; pl. 28, figs. 1, 2, (*not Lepidocyclina mortoni* Prever, 1912, Mem. Desc. Carta Geol., Roma, Italia, vol. 5, pt. 2, p. 187, pl. 8, figs. 1–3; pl. 9, fig. 7; pl. 13, fig. 1; pl. 14, fig. 7).

EXPLANATION OF PLATE 52

FIGS. *1, 2—Operculinoides ocalanus* (Cushman). *1*, median section, ×16; *2*, transverse section, ×16; core hole SL-84. (p. 270)
3—Operculinoides floridensis (Heilprin). Median section, ×16; core hole SL-84. (p. 270)
4—Lepidocyclina (*Pliolepidina*) *pustulosa* forma *tobleri* H. Douvillé. Vertical section, ×16; outcrop float. (p. 272)
5, 6—Lepidocyclina (*Pliolepidina*) *macdonaldi* Cushman. *5*, oriented vertical section, ×16; *6*, oblique vertical section which shows the shape of the equatorial chambers in the band through the center, ×16; outcrop float. (p. 272)
7, 8—Asterocyclina georgiana (Cushman). *7*, external view, ×5; *8*, portion of a vertical section, ×16; core hole SL-84. (p. 273)
9, 10—Helicolepidina spiralis Tobler. *9*, vertical section, ×16; *10*, median section, ×16; core hole SL-84. (p. 272)
11–13—Camerina striatoreticulata (L. Rutten). *11, 12*, median sections, ×16; *13*, transverse section, ×16; core hole SL-84. (p. 269)
14—Discocyclina (*Discocyclina*) *minima* (Cushman). Accidental vertical section, not centered, ×16; outcrop float. (p. 273)



Cole, Panama Canal Zone Eocene Foraminifera



Cole, Panama Canal Zone Eocene Foraminifera

Lepidocyclina (*Lepidocyclina*) *mortoni* Cushman (*not* Prever), GRAVELL and HANNA, 1935, Jour. Paleontology, vol. 9, pp. 337–339, pl. 30, figs. 1–9; pl. 31, figs. 1–11; pl. 32, figs. 1–4 (references);—COLE, 1945, Florida Geol. Survey Bull. 28, pp. 120–122, pl. 20, figs. 1–12.

It is regrettable that the name of this well-established species of the upper Eocene Moodys Branch formation (Jackson group) of the Gulf Coast of the United States is preoccupied by a European species for which the specific name *mortoni* was used by Prever in 1912. The name *montgomeriensis* from Montgomery, La. is proposed, as this locality is the type locality of the American species which has been known as *mortoni*.

This species is characterized by a thin, fragile test in the center of which there is usually a small umbo. The lateral chambers are extremely appressed so that the chamber cavity is slitlike. There are very few tiers of lateral chambers developed, even over the center of the test, and the peripheral margin of the test is normally composed of uncovered equatorial chambers.

The embryonic chambers are bilocular and subequal in size. There is considerable variation in size of the embryonic apparatus as demonstrated by the measurements made from the Panamanian specimens which follow:

Measurements of the embryonic apparatus in equatorial sections

Specimen	1	2	3	4
Internal diameters of initial chamber	530×670μ	520×620μ	500×600μ	880×880μ
Internal diameters of second chamber	200×560μ	240×490μ	220×660μ	300×820μ
Internal diameters across both chambers	740μ	760μ	720μ	1200μ

Measurements of the embryonic apparatus in vertical sections

Specimen	1	2	3	4
Internal length of both embryonic chambers	800μ	820μ	840μ	980μ
Internal height at highest portion	300μ	620μ	640μ	400μ

Gravell and Hanna (1935, p. 338) in their restudy of specimens of this species found that the embryonic apparatus measured "... as little as 0.388×0.433 mm. in specimens with the smaller embryonic apparatus to 0.660×0.833 mm. in those having the larger embryonic apparatus."

It is of interest to note that Schenck (1944, p. 279) gives a hypothesis that "... the proloculus of the Foraminifera does not exceed a diameter of 1 mm." In the species under discussion the embryonic apparatus reaches a diameter of 1.2 mm. internally or a diameter of 1.24 mm. externally.

Many of the specimens in the present collection appear to lack lateral chambers over the embryonic apparatus when observed in

EXPLANATION OF PLATE 53

FIG. *1*—*Asterocyclina* sp., probably small *A. georgiana* (Cushman). Slightly oblique vertical section, ×40; outcrop float. (p. 273)

2–11—*Lepidocyclina* (*Lepidocyclina*) *montgomeriensis* Cole, nom. nov. *2*, portion of an equatorial section of the microspheric specimen illustrated in vertical section as fig. *6* to show the shape of the equatorial chambers, ×40; core hole SL-84. *3*, oriented equatorial section, ×16; core hole SL-84. *4*, vertical section of a microspheric individual with the vertical section of a small megalospheric individual attached on the left side, ×16; core hole SL-84. *5*, vertical section of a megalospheric individual to show embryonic and lateral chambers, ×16; core hole SL-84. *6*, vertical section of a microspheric individual, ×40; core hole SL-84. *7*, *8*, oblique equatorial sections of megalospheric individuals, ×16; outcrop float. *9*, vertical section to demonstrate removal by erosion of the lateral chambers over the embryonic chambers, ×40; core hole SL-84. *10*, *11*, vertical sections of megalospheric individuals; *10*, ×16; *11*, ×40; outcrop float. (p. 270)

vertical section. However, other specimens have lateral chambers, although many of these show only two tiers of lateral chambers on each side of the test. In many of those which are devoid of lateral chambers, it appears as if these chambers had been removed by erosion.

It is worth noting that the individuals lie in the rock specimen one upon the other with practically no other materials intervening. This is particularly true of the core specimen, which is solidly composed of larger Foraminifera with very minor amounts of cementing material or other inorganic impurity.

Several microspheric specimens occur, and these, like the megalospheric forms, are entirely in accord with the descriptions and illustrations given of this species.

Subgenus PLIOLEPIDINA H. Douvillé, 1915
LEPIDOCYCLINA (PLIOLEPIDINA) MACDONALDI Cushman
Plate 52, figures 5, 6; Plate 54, figures 8, 10

Lepidocyclina macdonaldi CUSHMAN, 1918, U. S. Nat. Mus. Bull. 103, p. 94, pl. 40, figs. 1–6.

Lepidocyclina (*Lepidocyclina*) *macdonaldi* VAUGHAN, 1928, Jour. Paleontology, vol. 1, pp. 288, 289;—GRAVELL, 1933, Smithsonian Misc. Coll., vol. 89, no. 11, pp. 25, 26, pl. 5, figs. 1–3.

Lepidocyclina (*Pliolepidina*) *macdonaldi* VAUGHAN and COLE, 1941, Geol. Soc. America Sp. Paper 30, p. 67, pl. 31, figs. 1, 2;—COLE, 1945, Florida Geol. Survey Bull. 28, pp. 117–119, pl. 19, figs. 1–13.

This species is readily recognized in vertical sections by the shape and arrangement of lateral chambers. These have slitlike cavities between thick roofs and floors which are gently convex toward the exterior of the test.

This species has been reported from the upper Eocene of David, Panama; Jamaica; Venezuela; the Tampico Embayment; and the State of Chiapas, Mexico.

LEPIDOCYCLINA (PLIOLEPIDINA) PUSTULOSA (H. Douvillé)
Plate 54, figure 5; Plate 55, figure 8

Isolepidina pustulosa H. DOUVILLÉ, 1917, Paris Acad. Sci., C. R., vol. 161, p. 844, text figs. 1–4.

Lepidocyclina (*Pliolepidina*) *pustulosa* VAUGHAN and COLE, 1941, Geol. Soc. America Sp. Paper 30, pp. 65, 66, pls. 25–30 (references).

This species is represented in the present collection by a single horizontal section which is, however, very typical. The teratologic form *tobleri* is much more common than the typical form.

LEPIDOCYCLINA (PLIOLEPIDINA) PUSTULOSA forma TOBLERI (H. Douvillé), forma *teratologica*
Plate 52, figure 4; Plate 54, figure 9

Pliolepidina tobleri H. DOUVILLÉ, 1917, Paris Acad. Sci., C. R., vol. 164, p. 844, text figs. 5, 6.

Lepidocyclina (*Pliolepidina*) *pustulosa* forma *tobleri* forma teratologica VAUGHAN and COLE, 1941, Geol. Soc. America Sp. Paper 30, pp. 66, 67, pl. 24 (references and synonymy).

In the references to this species Vaughan and Cole overlooked the article by L. Rutten (1928), in which this species is discussed. Moreover, it should be indicated that the vertical section illustrated in this article as figure E of the plate, is not correctly identified. It is referred to *Lepidocyclina* aff.? *Polylepidina proteiformis* Vaughan, but it is a rather typical specimen of *tobleri*.

Cushman under the name *L. panamensis* (1919, pp. 94, 95, pl. 39, figs. 1–6; pl. 42) gives a series of vertical sections of this species which illustrate the features excellently. The vertical sections in the present collection are in absolute conformity with those previously published.

This species is known from Trinidad; Curaçao; State of Veracruz, Mexico; and Florida.

Genus HELICOLEPIDINA Tobler, 1922
HELICOLEPIDINA SPIRALIS Tobler
Plate 52, figures 9, 10

Helicolepidina spiralis TOBLER, 1922, Eclog. geol. Helvetiae, vol. 17, pp. 380–384, text figs. 1–3;—BARKER, 1934, Jour. Paleontology, vol. 8, pp. 345, 346, pl. 47, figs. 1–4; text figs. 1*a*, *c* (references and synonymy);—BARKER and GRIMSDALE 1936, Jour. Paleontology, vol. 10, p. 243, pl. 33, fig. 7;—VAUGHAN, 1936, Jour. Paleontology, vol. 10, p. 251, pl. 39, fig. 5; pl. 40, figs. 6–8;—VAUGHAN and COLE, 1941, Geol. Soc. America Sp. Paper 30, p. 76, pl. 45, fig. 1.

Rare specimens assigned to this species occur in the core from SL-84.

The type specimens of this species came from the upper Eocene of Trinidad. It has been reported also from Curaçao, northwest

Peru, Venezuela and the Tampico Embayment, Mexico.

Family DISCOCYCLINIDAE Vaughan and Cole
Genus DISCOCYCLINA Gümbel, 1870
Subgenus DISCOCYCLINA Gümbel, 1870
DISCOCYCLINA (DISCOCYCLINA) MINIMA (Cushman)

Plate 52, figure 14; Plate 54, figures 6, 7; Plate 55, figure 6

Orthophragmina minima CUSHMAN, 1918, U. S. Nat. Mus. Bull. 103, p. 97, pl. 41, fig. 1;—1919, U. S. Geol. Survey Prof. Paper 125, p. 41, pl. 7, fig. 3.
Discocyclina (*Discocyclina*) *minima* VAUGHAN, 1945, Geol. Soc. America Mem. 9, p. 76, pl. 25, figs. 4–7.

Several accidental sections of a species of *Discocyclina* with an inflated central portion surrounded by a thin rim occur in the thin sections of the float material. The resemblance of these specimens to illustrations of *minima* is so close that there is no hesitance in referring the specimens in the present collection to that species.

Three vertical sections, none of which are perfectly oriented, and one vertical section which is a megalospheric individual, are described and illustrated. The three unoriented sections may be the microspheric form.

The sections which represent the microspheric forms are described first. Of these, one has a diameter of 3.48 mm. and a thickness of 1.16 mm.; another has a diameter of 3.6 mm. and a thickness of 1.08 mm.; and the largest has a diameter of 7.0 mm. and a thickness of 1.44 mm. In the specimen with the smallest diameter the flange has a width of 0.5 mm., in the median specimen the flange width is about 1.0 mm. and in the largest specimen the flange has a width of about 2.5 mm.

The equatorial layer has a height at the center of the test of about 20 μ and expands slowly toward the periphery. In the smaller specimens the peripheral height is about 40 μ and in the larger specimen, about 80 μ.

There are about 20 lateral chambers to a tier on each side of the equatorial layer in one specimen and about 22 lateral chambers to a tier in the others. The chambers at the periphery and over the center have a length of 60 to 80 μ and a height of 20 to 24 μ with very thin floors and roofs, 5 to 10 μ thick. The chambers are arranged in regular tiers.

A small, oriented, vertical section of a megalospheric individual was discovered. The shape, size, and arrangement of the lateral chambers is so similar to the specimens just described that it was decided that this specimen represents the megalospheric form. A description of this section follows:

The central portion of the test is inflated, with a diameter of 1.7 mm. and a thickness of 1.06 mm. The peripheral edges are missing, but there is evidence that this central, inflated portion is surrounded by a broad, very thin rim.

The embryonic chambers are imperfectly shown, but consist of two chambers, a larger and a smaller chamber. The internal length of these two chambers is about 100 μ and the height at the highest part is 60 μ.

The equatorial layer is very thin, about 10 μ near the embryonic chambers, and about 20 μ at the point where the rim would join the central area.

The lateral chambers are very numerous for such a small form with 16 to 18 chambers to a tier on each side of the embryonic apparatus. Moreover, these lateral chambers have large, open cavities and very thin floors and roofs. The chambers are arranged in moderately regular tiers with an occasional chamber overlapping from one tier to another. Normal, peripheral lateral chambers have heights of 20 μ, lengths of about 60 μ, and the floors and roofs have thicknesses of about 4 μ.

Pillars are not present, but there is some thickening of the point of juncture of some of the tiers of lateral chambers which gives the appearance of very small fine pillars.

Genus ASTEROCYCLINA Gümbel, 1870
ASTEROCYCLINA GEORGIANA (Cushman)

Plate 52, figures 7, 8; Plate 53, figure 1; Plate 55, figures 1–5

Orthophragmina georgiana CUSHMAN, 1917, U. S. geol. Survey Prof. Paper 108-G, p. 117, pl. 41, figs. 2, 3; pl. 42, fig. 3; pl. 43, figs. 2, 3.
Discocyclina (*Asterocyclina*) *georgiana* COLE, 1944, Florida Geol. Survey Bull. 26, pp. 75, 76, pl. 1, fig. 15 (references);—VAUGHAN, 1945, Geol. Soc. America Mem. 9, p. 79, pl. 27, fig. 6, 7.

Test stellate with four rays, arranged in

the form of a cross, the intervening areas between the individual rays occupied by thinner, triangular-shaped areas, producing a quadrangular outline to the test of which the distal ends of the rays form the corners and the bases of the triangular areas the sides. Along one of the axes the test measures 6 mm. and along the other 8 mm. At the center of the test there is a small umbo with a diameter of about 1 mm. from which the rays radiate. The rays have a width of about 0.7 mm. just beyond the central umbo from which point they broaden slowly as they approach the periphery of the test to a width of about 0.9 mm. Small, fine papillae occur uniformly over the surface of the test interspersed between small shallow pits.

Vaughan (1945, p. 79, pl. 27, figs. 6, 7) has published recently an excellent photomicrograph of the embryonic apparatus of this species. For comparison with the Panamanian specimens, photomicrographs of topotype specimens from Red Bluff on the Flint River, Ga., are given on plate 55, figures 2–4.

Although the thin sections of the Panamanian species are not entirely satisfactory, they are sufficiently clear to demonstrate in conjunction with the distinctive external appearance that these specimens should be referred to this species.

Genus PSEUDOPHRAGMINA H. Douvillé, 1923
Subgenus PROPOROCYCLINA Vaughan and Cole, 1940

PSEUDOPHRAGMINA (PROPOROCYCLINA) FLINTENSIS (Cushman)

Plate 54, figures 1–4

Orthophragmina flintensis CUSHMAN, 1917, U. S. Geol. Survey Prof. Paper 108–G, p. 115, pl. 11 figs. 1, 2.

Pseudophragmina (Proporocyclina) flintensis VAUGHAN, 1945, Geol. Soc. America Mem. 9, pp. 89–92, pl. 36; pl. 37, fig. 1.

The preparations of the specimens referred to this species were the least satisfactory ones in the present collection. However, in such features as could be deciphered, there is close correspondence with those of typical *flintensis* which is an umbonate form. The only other species to which these specimens might be referred is *P. (P.) mirandana* (Hodson) which is a nonumbonate type and possesses more open lateral chambers than do the specimens in this collection.

A photomicrograph of a specimen from Florida is introduced for comparison with the specimens from Panama. This is illustrated as figure 3, plate 54.

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EXPLANATION OF PLATE 54

FIGS. *1–4—Pseudophragmina (Proporocyclina) flintensis* (Cushman). *1*, small portion of the equatorial section, fig. *2*, enlarged to show the shape of the equatorial chambers, ×170. *2*, equatorial section, ×16; core hole SL-84; *3*, oriented vertical section of a specimen from the Ocala limestone on the Chipola river at Marianna, Florida, introduced for comparison with the specimens from Panama, ×40. *4*, portion of a vertical section, ×40, core hole SL-84. (p. 274)

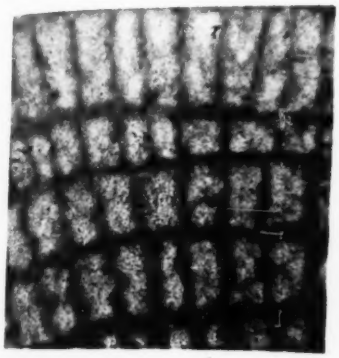
5—Lepidocyclina (Pliolepidina) pustulosa H. Douvillé. Oblique equatorial section, ×40, to show stoloniferous passages between the equatorial chambers; outcrop float. (p. 272)

6, 7—Discocyclina (Discocyclina) minima (Cushman). *6*, oriented vertical section of a megalospheric individual, ×40; *7*, unoriented vertical section of a microspheric individual, ×40, outcrop float. (p. 273)

8—Lepidocyclina (Lepidocyclina) montgomeriensis Cole, nom. nov. (left) and *Lepidocyclina (Pliolepidina) macdonaldi* Cushman (right). Vertical sections, ×16; outcrop float. (p. 270)

9—Lepidocyclina (Pliolepidina) pustulosa, forma *tobleri* H. Douvillé. Vertical section with some erosion of the lateral chambers, ×40; outcrop float. (p. 272)

10—Lepidocyclina (Pliolepidina) macdonaldi Cushman. Oblique vertical section to show lateral chambers, embryonic chambers, and equatorial chambers, ×40; outcrop float. (p. 272)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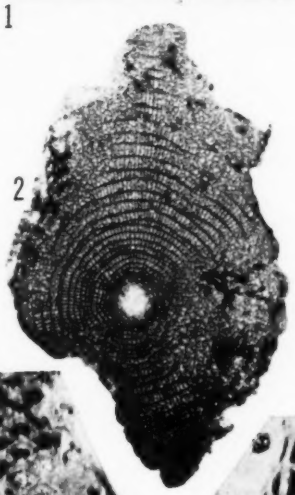
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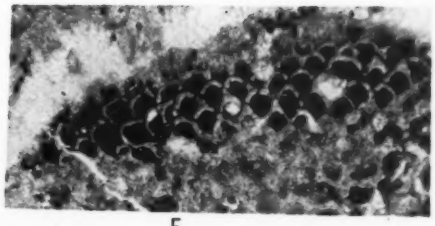
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Cole, Panama Canal Zone Eocene Foraminifera

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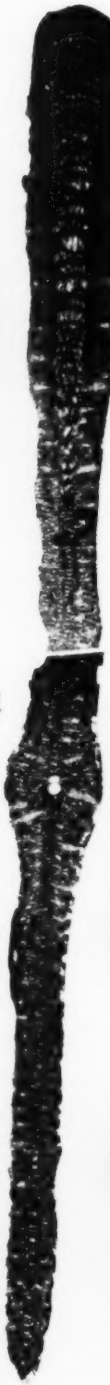

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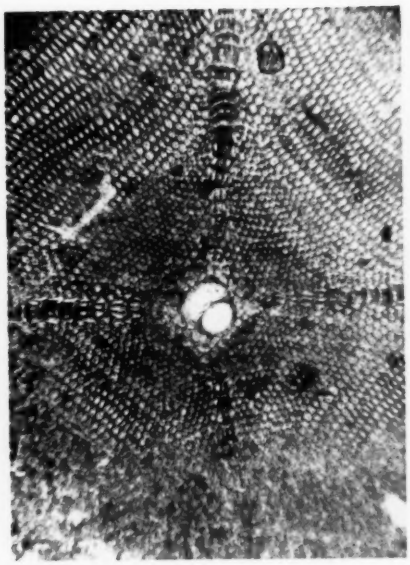

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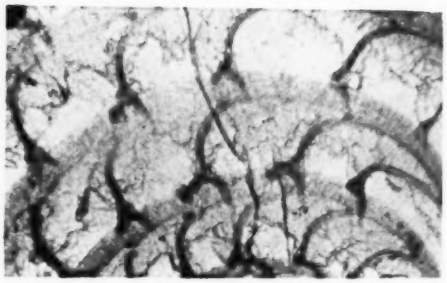

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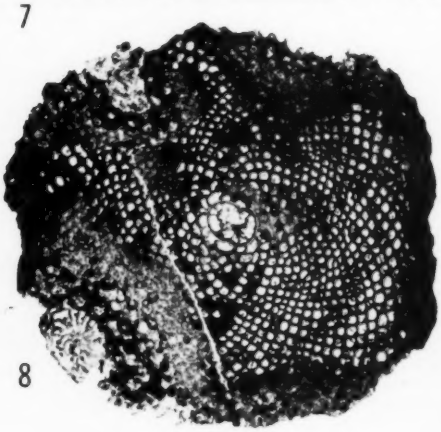

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Cole, Panama Canal Zone Eocene Foraminifera

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MANUSCRIPT RECEIVED AUGUST 11, 1948.

EXPLANATION OF PLATE 55

FIGS. *1–5*—*Asterocyclina georgiana* (Cushman). *1*, nearly oriented vertical section through central umbo, ×40; outcrop float. *2*, portion of an equatorial section, ×40. *3*, portion of the vertical section of the specimen, fig. *4*, enlarged, ×40. *4*, vertical section, ×16; *2–4*, from the Ocala limestone at Red Bluff, Ga., introduced for comparison with the specimens from Panama. *5*, vertical section, not absolutely centered, ×16; outcrop float. (p. 273)

6—*Discocyclina* (*Discocyclina*) *minima* (Cushman). Vertical section of microspheric specimen ×16; outcrop float. (p. 273)

7—*Camerina striatoreticulata* (L. Rutten). Small segment of a median section, ×40, to show the Y-shape processes on the proximal ends of the chamber walls; core hole SL-84. (p. 269)

8—*Lepidocyclina* (*Pliolepidina*) *pustulosa* H. Douvillé. Equatorial section to show normal embryonic chambers, ×16; core hole SL-84. (p. 272)

JOURNAL OF PALEONTOLOGY, VOL. 23, NO. 3, PP. 276–305, PLS. 56–64, 3 TEXT FIGS., MAY 1949

THE CEPHALOPOD FAUNA OF THE WHITE PINE SHALE OF NEVADA

WALTER YOUNGQUIST

ABSTRACT—A dark shale containing fossiliferous limestone lenses in its upper portion is extensively developed in eastern Nevada where it varies in thickness up to some 2000 feet. This formation was studied in six mountain ranges, and large collections of cephalopods have been assembled from four localities. Representatives of the genera *Mooreoceras*, *Cycloceras*, *Poterioceras*, *Endolobus*, *Liroceras*, *Discitoceras*, *Bactrites*, *Cravenoceras*, *Goniatites*, *Anthracoceras?*, *Eumorphoceras*, *Girtyoceras*, and *Epicanites?* are now known from the White Pine shale. They indicate that the containing beds are late Mississippian in age and are approximately equivalent to the following: the Caney shale of Oklahoma; the Barnett and Helms formations of Texas; the Moorefield, Ruddell, Batesville, and Fayetteville formations of northern Arkansas; Meramec beds in Kentucky; and part, at least, of the Floyd shale of Georgia. Faunal elements regarded in Europe as indicative of the middle and upper Viséan and others which are considered diagnostic of the lower Namurian occur in direct association at several localities in the White Pine shale.

The White Pine shale is a thick, rather widely distributed but relatively little-known formation which has its type area in the White Pine Mountains of east-central Nevada. Stratigraphically, it lies between the Devonian Nevada limestone[1] below, and the Mississippian? Diamond Peak quartzite above. The White Pine shale is now known to crop out in several other of the Nevada mountain ranges. Its easternmost known exposure is in the southern portion of the Snake Range. In a westward direction, this formation is successively exposed in the Schell Creek Range, the Egan Range, the White Pine Range, an eastern spur of the Pancake Range, and the Diamond Range. It is also known to occur in the Inyo Mountains of southeastern California. Topographically the White Pine shale is well marked. Because of its great thickness (up to about 4500 feet) the Nevada limestone, which underlies the White Pine shale in eastern Nevada, is very prominent, forming many of the major mountain ridges. Likewise, the Diamond Peak quartzite, together with the overlying limestones which occur stratigraphically above the White Pine shale in east-central Nevada, also form prominent ridges. Consequently, the White Pine shale is usually expressed topographically as a valley. Very locally, however, the more calcareous or arenaceous portions of the formation may form small hills within the general valley trough.

Lithologically the White Pine is predominantly a dark, carbonaceous shale. Locally, some thin sandstone beds are present but the great mass of the formation is a brown or black fissile shale. However, the upper portion (usually less than 200 feet) of the White Pine bears marine limestone lenses a few inches to three or four feet in thickness, which at some localities are abundantly fossiliferous. At least in the Schell Creek and Snake ranges these discontinuous limestone beds appear to be confined to the upper 50 feet of the formation.

The fossils are predominantly cephalopods, and goniatites are much more abundant than nautiloids. Second in abundance to the goniatites is the small pelecypod which Meek (1877, pp. 93–95) originally described as *Aviculopecten catactus* from the White Pine shale at its type locality in the White Pine Mountains. A few gastropods or impressions thereof are occasionally found, and very poorly preserved plant remains are also present in the portion of the formation

[1] A broad term used in this report (as in Hague's 1892 monograph) to include all the Devonian limestones and shales of the Nevada limestone, *s. l.*, in east-central Nevada. The "Nevada limestone" of the Roberts Mountains region is now divided (Merriam, 1940, p. 14) into two units, the Nevada formation and the Devils Gate formation. These divisions, however, are not always apparent in all the areas wherein the cephalopods were secured from the overlying White Pine shale.

well below the cephalopod-bearing beds. However, it should be noted that the greater part of the formation, although highly carbonaceous, is markedly unfossiliferous.

Some parts of the White Pine shale exhibit small oil seeps, and layers of earthy bituminous material a foot or so thick occur in the formation in the upper part of Murphy Wash, in the southern portion of the Snake Range. Also, some of the goniatites of the White Pine shale in a northeastern spur of the Pancake Range are in part hollow and contain a dark petrolic liquid which flows freely when the specimens are broken. An interesting parallel to this condition has been described by Miller and Owen (1937, p. 404) in their paper on cephalopods from the Pennsylvanian Seminole formation of Oklahoma. They state that "in a few of the many broken specimens collected, some of the camerae had not been entirely filled with stony material but instead were lined with inwardly projecting crystals of calcite and were filled with black viscous petroleum." This description is equally apt for certain of the White Pine cephalopods.

In east-central Nevada the White Pine shale varies in thickness from some 100–500 feet in the Snake Range to about 2000 feet in the White Pine and Pancake ranges. Kirk (1918, p. 38) reported that the White Pine attains a thickness of slightly more than 1000 feet in the Inyo Range of southeastern California. He (Kirk, 1918, p. 40) also noted that in the Inyo Range the Diamond Peak quartzite "unconformably overlies the series of basal Pennsylvanian limestone." That is, there the quartzite does not directly overlie the White Pine shale as it does in east-central Nevada. Kirk regarded the Diamond Peak quartzite as Pennsylvanian in age. Later, however, Wilmarth (1938, p. 608) stated that Girty believed the fossils contained in the Diamond Peak quartzite to be of upper Mississippian age, and he is being tentatively followed.

PREVIOUS WORK

The occurrence of a cephalopod fauna in the thick dark shale overlying the Devonian limestones of eastern Nevada was first recorded by Hall and Whitfield in 1877. They established a nautiloid species, *Cyrtoceras cessator*, and one of ammonoids, *Goniatites kingii*, based on specimens secured from "black shales of probably Coal-Measure age, near Eberhardt Mill, White Pine, Nevada." These cephalopods were collected by Hague, who was at that time making stratigraphic studies in east-central Nevada for the United States Geological Survey. Later, in reporting the progress of his studies on the geology of the Eureka district, Hague (1883, p. 266) proposed the name "White Pine" for "a heavy body of black shale [which was] first recognized as a distinct horizon in the White Pine mining district." In this preliminary report and later in his monograph on the geology of the Eureka district, Hague (1892) regarded the White Pine shale as Devonian in age. Also, Walcott (1884), in his study of the paleontology of the Eureka district, gave a short list of fossils from the White Pine shale and placed that formation at the top of the Devonian section in Nevada. In a discussion of "the recurrence of Devonian fossils in strata of Carboniferous age," Williams (1895, p. 98) referred briefly to the White Pine shale and apparently followed Walcott and Hague in assigning it to the "pre-Carboniferous."

Girty (1905, pp. 11–12), in a cursory survey of some of the Carboniferous marine faunas of The United States, appears to have been the first to regard the White Pine shale as definitely post-Devonian. He stated that he had long been of the opinion "that the age of this bed is not Devonian, but Carboniferous" adding, however, that the White Pine fauna "is not without forms suggestive of the Devonian."

Some small additions to the knowledge of the distribution of the White Pine shale and its possible equivalents were made by Spurr (1903), Hill (1916), Spencer (1917), Merriam (1940), and Roberts (1942). In 1943, Nolan (pp. 153–155) briefly summarized the existing knowledge of the Mississippian in the Basin and Range province. Perhaps the most important contribution was that by Kirk in 1918. He reported the occurrence of a shale in the Inyo Range of southeastern California which yielded cephalopods and brachiopods indicative of a Mississippian age for the containing beds. Girty (*in* Kirk, 1918) studied the assemblage from California and noted (p. 39) that it "is an interesting

and peculiar fauna of the Caney shale of Oklahoma, and the related but less well-known fauna of the White Pine shale of Nevada. These faunas I [Girty] refer to the upper Mississippian."

Relatively recently Miller and Furnish (1940) published a study of two small collections of ammonoids from the White Pine. One of these came from the southern portion of the Snake Range, the other from the Cave Valley area of the Egan Range, both in east-central Nevada.

PRESENT STUDY

A field investigation of the cephalopod fauna of the White Pine shale was undertaken in the summer of 1946. The formation was studied in six mountain ranges in Nevada and cephalopods were secured from widely separated places in four of the ranges. These localities are discussed in detail in the following paragraphs, and the cephalpod fauna known from each is listed.

Snake Range (Locality 1).—The easternmost of the major mountain ranges in Nevada is the Snake Range. It trends essentially north-south, and closely parallels the Nevada-Utah boundary. A portion of the northern part of this same general structure makes a short eastward bend into Utah, and then continues northward for about 45 miles. This Utah portion of the Snake Range uplift is usually termed the Deep Creek Mountains. The Snake Range proper is about 85 miles in length and its dominant point is Wheeler Peak, 13,047 feet altitude. South of Wheeler Peak the Snake Range exhibits a number of sedimentary formations, prominent among which are Devonian and Pennsylvanian limestones. The White Pine shale is exposed in upper part of Murphy Wash some 16 miles south of Wheeler Peak. The structure of this area is complex, but the formation appears to attain a thickness of at least 500 feet. No fossils were found at this locality. However, about 1½ miles east of the trail up Murphy Wash, and approximately in the SE¼ Sec. 2, T. 10 N., R. 68 E., White Pine County, Nevada, the upper portion of the White Pine shale with its goniatite-bearing limestone lentils is exposed in a very small area. This place is near the head and on the west side of a small valley locally known as "John's Hollow." Here the shale is only a few hundred feet thick. The area is minutely faulted and the total exposure of the fossiliferous limestone zones interbedded with shale is only about 200 feet long and 40 feet wide. Cephalopods occur in limestone lenses a few inches thick in the very upper part of the shale to within a few feet of the base of the overlying and stratigraphically higher Diamond Peak quartzite. According to J. M. Fox of Shoshone, Nevada, this locality is the same one from which he secured the goniatites described and figured by Miller and Furnish (1940) and reported to occur in "black shale or shaly limestone near the southern end of the Snake Range in easternmost Nevada." The following cephalopods are now known from this exposure:

Mooreoceras depressum, n. sp.
Mooreoceras sp.
Cycloceras? sp.
Posterioceras? spp.
Endolobus occidens, n. sp.
Endolobus ornatus Girty
Liroceras sp.
Discitoceras texanum Miller and Youngquist
Bactrites nevadense, n. sp.
Cravenoceras hesperium Miller and Furnish
Cravenoceras merriami, n. sp.
Cravenoceras nevadense Miller and Furnish
Goniatites choctawensis Shumard
Anthracoceras? columbrellus Miller and Furnish
Eumorphoceras bisulcatum Girty

Schell Creek Range (Locality 2).—Paralleling the Snake Range some 10 to 14 miles west of it is the Schell (also spelled "Shell") Creek Range. In various parts of these mountains marine sedimentary rocks ranging in age from Cambrian to Pennsylvanian are present. Two highways (U. S. 6 and U. S. 93) funnel together across the range in its central portion via a relatively low point in the uplift, Connor's (also spelled "Conner's") Pass, 6997 feet above sea level. The White Pine shale is exposed continuously along the north side of the highway from about half a mile west of the pass to about three-quarters of a mile west of it. The valley which the road follows in this locality is also cut in the shale. About 100 yards north of the highway and .7 mile west of Connor's

Pass, there is a zone of iron-stained limestone beds some 5 feet thick. This locality is in section 34, T. 14 N., R. 65 E., White Pine County, Nevada. Here, goniatites occur in abundance and nautiloids are not rare. However, the preservation is in part limonitic, and therefore many of the specimens tend to be friable, and crumble easily.

The structure of this area is complex but at the precise collecting locality the beds in general dip slightly to the north. The Diamond Peak quartzite occurs a few feet above the cephalopod-bearing beds of the White Pine shale. Below this fossiliferous zone, the formation exhibits the characteristic development of a thin-bedded black or dark brown fissile shale. One or two road cuts in this area along U. S. 6 and 93 expose the formation rather well. From this locality the following cephalopods have been collected:

Mooreoceras aff. *M. crebriliratum* (Girty)
Mooreoceras sp.
Cycloceras? sp.
Cycloceras ballianum Girty
Endolobus ornatus Girty
Cravenoceras hesperium Miller and Furnish
Cravenoceras nevadense Miller and Furnish
Cravenoceras merriami, n. sp.
Goniatites choctawensis Shumard?
Epicanites? sp.

Egan Range (Locality 3).—Just west of Cave Valley, which separates a southern part of the Schell Creek Range from the Egan Range, the Paleozoic rocks are broadly uplifted, and in this portion of the eastern side of the Egan Range they dip more or less eastward. The first valley west of Cave Valley is long and narrow and it trends northeastward in the Egan Range. The eastern edge of this valley is formed by a resistant ridge of Diamond Peak quartzite. Massive beds of the Nevada limestone form the western side of the valley. The valley proper is cut in the White Pine shale. A fossiliferous locality was discovered in the shale of this area. It is approximately in section 32, T. 10 N., R. 63 E., White Pine County, Nevada, at the northwestern "corner" of the valley where it broadens out and turns abruptly eastward. This place is about 1½ miles west of a small area of rather prominent volcanic ash beds locally known as the "White Cliffs." Only a few cephalopods were found here, and they all are referable to *Cravenoceras nevadense*. Some 25 years earlier, Mr. J. M. Fox visited this general area and collected the specimens which were described and illustrated in the Miller-Furnish report of 1940. All of those specimens (about 25) were placed in one species and were made the syntypes of *Cravenoceras nevadense* Miller and Furnish. During the field studies for the present report, in 1946, Mr. Fox together with the writer could not find the precise locality which yielded the types of *C. nevadense*. However, Mr. Fox stated that the place just described, and his original collecting locality were very close.

White Pine Range.—The type area of the White Pine shale is in the White Pine Mountains in the vicinity of Hamilton and Eberhardt, Nevada. The Hamilton region was originally called the White Pine mining district. Hamilton is situated in the northern part of the range at an elevation of approximately 8000 feet, and, although once possessing a population of some 20,000 persons, is now a ghost town. The central feature of this region is "Treasure Hill," famous for its silver mines. This prominence has a north-south trend, is composed of the Devonian Nevada limestone, and is essentially an asymmetrical anticline which has been broken along the eastern side of the summit of the hill. Cathedral Canyon, adjacent to Treasure Hill on the east and south, is cut in the White Pine shale. The town of Hamilton is at the north end of Treasure Peak, at the very upper end of Cathedral Canyon, and is situated in part on the White Pine shale. East of the upper part of Cathedral Canyon, Mokomoke Ridge exposes the Diamond Peak quartzite and the overlying limestones. The White Pine shale reappears to the east of Mokomoke Ridge in a broad north-south trending anticline in Ilipah Canyon and southeast of Mokomoke Ridge in Applegarth Canyon. Hague (1870, opp. p. 417) has shown the general structure and stratigraphic relations extant in the region of the type area of the White Pine shale. Also, Spurr (1903, pp. 61–68, figs. 1, 2) described the area in some detail and noted the occurrence of the White Pine to the east of the type area. No cephalopods were

found in the White Pine Range by the writer. However, Hague, in his early reconnaissance of the area, secured a few specimens which were described by Hall and Whitfield (1877, pp. 278–280, pl. 6, figs. 9–15) from "black shale of the Coal-Measures, near Eberhardt Mill, [about 4 miles south of Hamilton] White Pine." These paleontologists coined the following names for this material.

Cyrtoceras [*Cycloceras?*] *cessator*
Goniatites [*Cravenoceras*] *kingii*

Pancake Range (Locality 4).—No White Pine cephalopods have been secured from the Pancake Range proper. However, in Railroad Valley (which lies between the White Pine and Pancake ranges) there is a discontinuous series of small uplifts in northeastern Nye County and southwestern White Pine County, both north and south of the Nye County postoffice of Duckwater. Cephalopods have been secured from the White Pine shale at a single locality in this area. Hill (1916, pl. 1 opp. p. 20) has diagrammed these north-south trending ridges rather well and shows (as is the case in the field) that a small valley intervenes between them and the Pancake Range proper. However, other maps (*e.g.*, General land office map, State of Nevada, 1941) include these features in the Pancake Range. Since these hills seem to be structurally as well as geographically closer to that range than to the White Pine Mountains, they are here regarded as a spur of the Pancake Range. Although these ridges have a total length of over 40 miles, like many other such features in Nevada, they appear to have no name. Some five miles north of Duckwater, one of these small uplifts is divided into two ridges; the higher ridge to the east is composed of basalt and volcanic ash; the western one is formed by the massive Devonian Nevada limestone. The shallow valley intervening is in the White Pine shale which is some 1400 to 2000 feet thick at this place and is rather steeply tilted, dipping toward the east. Only a few hundred feet from volcanics, the characteristic cephalopod-bearing limestones of the White Pine shale are exposed in a nearly vertical attitude across one small hill about 100 yards long. Cephalopods were first found here by Dr. Charles W. Merriam and Mr. C. J. Anderson several years ago. Goniatites are very abundant, and nautiloids moderately so. They occur in limestone lenses a few inches thick and a foot or two in length; their preservation is excellent. As nearly as can be determined, this fossil locality is in section 28, T. 13 N., R. 56 E., Nye County, Nevada. It should be noted that the northern part of this general uplift is included on the southeast corner of atlas sheet 12 of Hague's "Geology of the Eureka District" (1892) and shows a mapped area

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EXPLANATION OF PLATE 56

All specimens illustrated on this plate are from the White Pine shale of east-central Nevada.

FIGS. *1–9*—*Mooreoceras* sp. Figures *1–4*, three specimens from the central portion of the Schell Creek Range, White Pine County. Part of a phragmacone and living chamber ×1 (fig. *1*); lateral and apical views of a small fragmentary phragmacone, ×1½ (figs. *2*, *3*); a relatively large phragmacone, ×1 (fig. *4*). Figures *5–8*, two individuals from the southern portion of the Snake Range, White Pine County. Apertural and lateral views of a fragmentary phragmacone, ×1½ (figs. *5*, *6*); apical and lateral views of 3 camerae, ×2 (figs. *7*, *8*). Figure *9* represents a completely septate specimen from an eastern spur of the Pancake Range, about 5 miles north of Duckwater, Nye County, ×1. (p. 284)

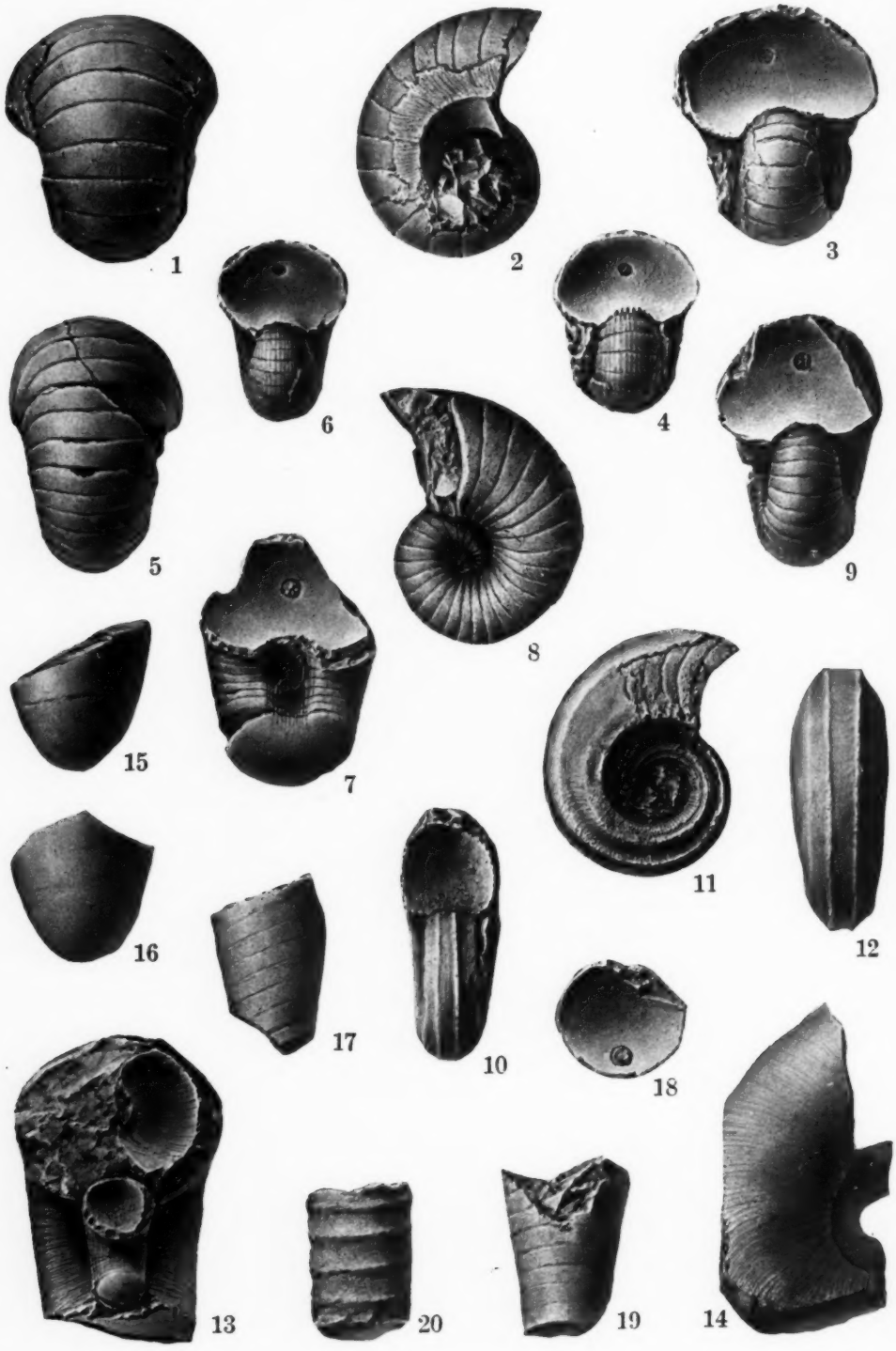
10, 11—*Mooreoceras depressum* Youngquist, n. sp. Apertural and dorsal views of the holotype, from the southern portion of the Snake Range, White Pine County, ×1½. (p. 283)

12–15—*Bactrites nevadense* Youngquist, n. sp. Lateral and apertural views of the holotype (figs. *12*, *13*) and lateral and apical views of the largest but somewhat distorted paratype (figs. *14*, *15*), both from the southern portion of the Snake Range, White Pine County, ×1½. (p. 289)

16, 17—*Mooreoceras* aff. *M. crebriliratum* (Girty). Two views of a fragmentary specimen from the central portion of the Schell Creek Range, .7 mile west of Connor's Pass, White Pine County, ×2. (p. 284)

18—*Cycloceras?* sp. A fragmentary specimen from the same horizon and locality as the preceding. ×2. (p. 285)

Youngquist, Nevada Mississippian Cephalopods



Youngquist, Nevada Mississippian Cephalopods

of White Pine shale. From the locality just described, the following cephalopods were secured.

Mooreoceras sp.
Liroceras sp.
Cravenoceras hesperium Miller and Furnish
Cravenoceras nevadense Miller and Furnish
Cravenoceras merriami, n. sp.
Cravenoceras scotti Miller and Youngquist
Goniatites choctawensis Shumard
Eumorphoceras plummeri Miller and Youngquist
Girtyoceras meslerianum (Girty)

For the sake of completeness it should be added that Kirk (1918, pp. 38–39) found a fossiliferous zone in the White Pine shale in the Inyo Range of southeastern California. That locality is "in the black fissile shale, which is well exposed along the Cerro Gordo Spring trail, about 1½ miles north of the [Cerro Gordo] mine." The following cephalopods have been identified by Girty from this place.

"*Orthoceras*" spp.
"*Gastrioceras*" aff. "*G.*" *richardsonianum* Girty
Goniatites sp.
Eumorphoceras bisulcatum Girty?

As was pointed out by Girty this is clearly the White Pine fauna.

In composite, the following cephalopods are now known from the White Pine shale at the Nevada localities just described:

Mooreoceras depressum, n. sp.
Mooreoceras aff. M. *crebriliratum* (Girty)
Mooreoceras sp.
Cycloceras ballianum Girty
Cycloceras? cessator (Hall and Whitfield)
Cycloceras? sp.
Poterioceras? spp.
Endolobus ornatus Girty
Endolobus occidens, n. sp.
Liroceras spp.
Discitoceras texanum Miller and Youngquist
Bactrites nevadense, n. sp.
Cravenoceras hesperium Miller and Furnish
Cravenoceras kingii (Hall and Whitfield)
Cravenoceras merriami, n. sp.
Cravenoceras nevadense Miller and Furnish
Cravenoceras scotti Miller and Youngquist
Goniatites choctawensis Shumard
Anthracoceras? columbrellus Miller and Furnish
Eumorphoceras bisulcatum Girty
Eumorphoceras plummeri Miller and Youngquist
Girtyoceras meslerianum (Girty)
Epicanites? sp.

Altogether, more than 3000 cephalopods were collected during the field season of 1946 from four localities, one each in the Snake, the Schell Creek, the Egan and the Pancake ranges. The easternmost and westernmost localities in the Snake and Pancake ranges, respectively, yielded the majority of the specimens. These two places are some 75 airline miles apart.

EXPLANATION OF PLATE 57

All specimens illustrated on this plate are from the White Pine shale of east-central Nevada.

FIGS. *1–4*—*Liroceras* sp. Figures *1–3*, ventral, lateral, and apertural views of the complete specimen, and (fig. *4*) apertural view of the juvenile volutions of the same individual, from the southern portion of the Snake Range, White Pine County, all ×2. (p. 289)

5–9—*Liroceras* sp. Figures *5*, *7*, *8*, ventral, lateral, and apertural views of the complete specimen; figure *6*, apertural view of the early whorls retaining traces of the test ornamentation; figure *9*, dorsal view of the outer half-volution; from an eastern spur of the Pancake Range, about 5 miles north of Duckwater, Nye County, all ×2. (p. 289)

10–12—*Discitoceras texanum* Miller and Youngquist. Three views of a well-preserved specimen from the southern portion of the Snake Range, White Pine County, ×2. (p. 286)

13, 14—*Endolobus occidens* Youngquist, n. sp. Dorsal and lateral views of the holotype, from the southern portion of the Snake Range, White Pine County, ×1½. (p. 287)

15–19—*Poterioceras?* spp. Figures *15*, *16*, represent one specimen as do figures *17–19;* both from the southern portion of the Snake Range, White Pine County, ×1. (p. 285)

20—*Cycloceras ballianum* Girty. A small portion of a phragmacone, from the central portion of the Schell Creek Range, .7 mile west of Connor's Pass, White Pine County, ×2. (p. 285)

With the exception of the Egan Range locality, all the location data used in the foregoing descriptions are derived from the U. S. Forest Service map of the Nevada National Forest, Nevada and Moapa divisions, edition of 1937, based on the Mt. Diablo meridian. The Egan Range locality data are based on information secured from combined use of State of Nevada Department of Highways maps, edition of 1937, of White Pine and Nye county sheets.

In a discussion of the distribution of the White Pine shale it should be added that the best exposure of this formation known to the writer is along the eastern side of the Diamond Range. Hague has mapped and discussed the area in detail. Although no cephalopods have so far been found there, the White Pine shale and its relations to both the underlying and overlying formations can be readily seen the length of Hayes (locally known as "Toll House") Canyon, and particularly along the southeastern side of Diamond Peak just north of the upper portion of Water Canyon. Here, too, near the top of the shale, marine limestone beds are well developed, but they are not very fossiliferous. Only some fragmentary crinoid remains and indeterminable molluscan fragments have been secured from this area.

GENERAL COMPOSITION AND SIGNIFICANCE OF THE CEPHALOPOD FAUNA

Of the more than 3000 cephalopods collected for this study, by far the most abundant generic form is *Cravenoceras*. *Goniatites s. s.* is the next most common, there being approximately 90 individuals represented in the collections at hand. Only three specimens of *Eumorphoceras* were found, and *Girtyoceras* and *Epicanites?* are each represented by but a single specimen. Nautiloids are comparatively rare in the White Pine fauna; the genus *Mooreoceras* is relatively the most abundant form, some 30 specimens having been collected. All the cephalopods which have been secured came from near the top of the White Pine shale. The composition of the fauna at all localities is very much the same, and there can be little doubt that the containing beds were of essentially contemporaneous deposition.

The age-significant elements of the fauna are the genera *Eumorphoceras*, *Girtyoceras*, *Goniatites s. s.*, and *Cravenoceras*. These occur in direct association in the White Pine shale. In Europe, *Goniatites s. s.* is regarded as diagnostic of the middle and upper Viséan whereas *Eumorphoceras* and *Cravenoceras* are said to appear first in the lower Namurian. In America, the probable direct association of some of these forms was first noted by Girty (*in* Kirk, 1918, p. 39) in the White Pine shale of southeastern California. Later, Plummer and Scott (1937, p. 15) listed the same association from the Barnett shale of Texas, as did Cloud and Barnes (see refs.). A detailed study has now been made on the Barnett cephalopod fauna by Miller and Youngquist (1948), and the stratigraphic occurrence and significance of *Eumorphoceras* and *Goniatites s. s.* has been discussed at some length. The extensive collections of cephalopods now available from the White Pine shale of Nevada show again that in America at least, *Goniatites s. s.* and *Eumorphoceras* are elements of a single fauna.

As has been noted by Miller and Youngquist (1948, p. 651), the correlation of the White Pine fauna with the classical Mississippian section of the middle Mississippi Valley region is indeed difficult because very few ammonoids are known from the latter area. However, the equivalents of the White Pine shale among certain other American formations are readily recognized. Prominent among contemporaneous beds is the Barnett formation of Texas. A Barnett cephalopod fauna, which was collected by Cooper, Cloud, and Barnes, has been available for direct comparison with the White Pine specimens. These two assemblages are remarkably close, both in general composition and in detail. In both faunas the nautiloids are represented by only a relatively few specimens of *Mooreoceras*, *Poterioceras*, *Endolobus* and *Discitoceras*. The most common ammonoid in each assemblage is *Cravenoceras*. *Goniatites s. s.* is next most abundant. *Eumorphoceras* is represented in both faunas by two species, *E. bisulcatum* and *E. plummeri*. *Girtyoceras meslerianum* is relatively rare, but it occurs in the White Pine shale and in the Barnett. About the only recognizable difference between these two assemblages is the absence of *Lyrogoniatites* from the White Pine fauna, and it does not

appear to be significant. In addition to the cephalopod fauna, it is interesting to note that at many localities the lithologies of the Barnett and the White Pine are strikingly similar. That is, the Barnett is in places a dark, fissile, petroliferous shale with limestone lenses in its upper portions just as is the White Pine shale. In addition, cephalopod faunas which appear to be very closely related to, or essentially identical with that found in the White Pine shale of Nevada and southeastern California are known to occur also in the following: the Helms formation of west Texas; the Caney shale of Oklahoma; the Moorefield, Ruddell, Batesville and lower Fayetteville formations of Arkansas, the "Meramec" beds in Kentucky, and the Floyd shale of Georgia.

SUMMARY AND CONCLUSIONS

The White Pine shale is of widespread occurrence in east-central Nevada, and in its upper portion it contains an abundant cephalopod fauna preserved in limestone lenses. More than 3000 specimens have been secured from the formation at localities in four mountain ranges. The great majority are ammonoids, referable to the genus *Cravenoceras*. *Goniatites s. s.*, *Eumorphoceras*, *Girtyoceras*, and *Epicanites?* are also represented. Nautiloids are relatively rare, but specimens belonging in *Mooreoceras*, *Cycloceras*, *Posterioceras?*, *Endolobus*, *Discitoceras*, *Liroceras*, and *Bactrites* have been collected. These genera indicate that the containing beds are approximately contemporaneous with the following: the Helms and Barnett formations of Texas; the Caney shale of Oklahoma; the Moorefield, Ruddell, Batesville, and lower Fayetteville formations of Arkansas; the "Meramec" beds of Kentucky, and the cephalopod-bearing portions of the Floyd shale of Georgia. *Goniatites s. s.* and *Eumorphoceras*, which in Europe are regarded as diagnostic of the middle and upper Viséan and the lower Namurian, respectively, occur in direct association in the White Pine shale.

ACKNOWLEDGMENTS

Particular thanks are due Professor A. K. Miller of The State University of Iowa, who has generously given supervision, technical advice, and editorial suggestions to this project from its beginning. Information in regard to the local geology and terrain of several mountain ranges of eastern Nevada, together with valuable field assistance, was contributed by Mr. J. M. Fox of Shoshone, Nevada, and Mr. C. J. Anderson of Eureka, Nevada. Dr. Charles W. Merriam first reported the occurrence of cephalopods in the White Pine shale of the Pancake Range area, and supplied details as to the precise locality. The able and enthusiastic field assistance of Mr. Bruce C. Heezen during the summer of 1946 contributed in large measure toward securing the extensive collections of fossils on which this study is based. The accompanying illustrations are photographs which were retouched by Mr. Howard E. Webster of Iowa City.

For the sake of comparison, illustrations of certain specimens from the Barnett shale of Texas, the Caney shale of Oklahoma, and the "Meramec" of Kentucky, have been included in this study. This material is in the collections of the United States National Museum, Princeton University, and The State University of Iowa. A few of the illustrations used for comparison are from the Miller-Furnish Carboniferous ammonoid study of 1940.

SYSTEMATIC PALEONTOLOGY

MOOREOCERAS DEPRESSUM Youngquist, n. sp.

Plate 56, figures 10, 11

Conch broadly rounded dorsally, somewhat more narrowly rounded laterally, and flattened ventrally. The holotype is septate throughout and is approximately 39 mm. in maximum length. At the adapical end of the specimen the conch is about 10½ mm. high, and slightly more than 11 mm. wide. Corresponding adoral measurements are some 15 mm. and 17 mm., respectively. These figures indicate that this individual expanded orad rather gradually and that the compressed nature of the conch is a relatively mature characteristic. The sutures are essentially simple circles, the septa are only moderately concave adapically, and at the adapical end of the holotype four camerae occupy a length of 10 mm. The

siphuncle is small at least at its passage through the septa. At the adoral end of the holotype, where the conch is about 15 mm. high, the siphuncle is situated slightly more than 4 mm. from the venter and is approximately a millimeter in diameter.

No part of the test is retained on the holotype, but traces of it which are impressed on the dorsal portion of the internal mold indicate that the growth lines there were essentially straight and directly transverse.

The depressed cross section of the fully mature portion of the conch (fig. 10) and the position of the small siphuncle are the chief characteristics of this species. No closely similar forms are known, so that specific comparisons would be superfluous.

Occurrence.—White Pine shale, Snake Range, Nevada (locality 1).

Holotype.—State Univ. Iowa, 4938.

MOOREOCERAS aff. M. CREBRILIRATUM (Girty)
Plate 56, figures 16, 17

A fragmentary orthocone from the Schell Creek Range is unique among the nautiloids under consideration. It has a circular or a subcircular (possibly due to distortion) cross section. The siphuncle is subcentral in position, and is small, at least at its passage through the most adapical of the preserved septa. The adoral fourth of the specimen is non-septate and presumably represents living chamber. The septa are moderately convex adapically. Much of the test is retained and its surface ornamentation consists of moderately fine transverse lirae. There appear to be no annulations.

This specimen resembles somewhat *M. crebriliratum* of the Caney shale of Oklahoma, the Barnett of Texas, and possibly the Moorefield of Arkansas. However, the holotype of the Caney species has much finer shell ornamentation. The White Pine specimen probably represents a new species, but it is too poorly preserved to serve as a holotype.

Occurrence.—White Pine shale, Schell Creek Range, Nevada (locality 2).

Figured specimen.—State Univ. Iowa, 4939.

MOOREOCERAS sp.
Plate 56, figures 1–9

The collections under consideration contain some 25 specimens which appear to be referable to the genus *Mooreoceras*, but they do not retain sufficient characteristics so that their specific affinities can be determined with certainty. More than one species may be represented although all specimens appear to be quite similar. The conch is circular or nearly so in cross section, is gradually expanded orad, and is rather slender. The siphuncle is small, at least at its passage through the septa, and it is slightly subcentral in position. The sutures are essentially simple circles. In all of the specimens the camerae are fairly short, and there are on the average about three of them in a length equal to the diameter of the conch. Most of these individuals do not preserve the test; however, traces of that structure on the specimen illustrated by figure 1 on Plate 56 indicate that the test bore fine transverse lirae. Part of the living chamber is also preserved on this specimen.

The largest illustrated specimen (fig. 4), although incomplete both adorally and adapically, is about 93 mm. in length. At its adapical end, it is some 7 mm. in diameter, and its adoral diameter is approximately 19 mm. The largest representative of *Mooreoceras* in the collections is a fragmentary unfigured specimen from the Pancake Range. It preserves a part of a septum and a portion of what appears to have been living chamber. The maximum diameter of the conch is clearly indicated, being slightly over 35 mm.

Specific comparisons cannot be made satisfactorily, but it should be noted that these specimens appear to be close to and possibly conspecific with such forms as *Mooreoceras* sp. of Girty from the Moorefield of Arkansas, *M.* sp. of Miller and Furnish from the "Meramec" of Kentucky, *M. indianum* (Girty) of the Caney of Oklahoma, and *M. crebriliratum* (Girty) of the Caney of Oklahoma and the Barnett of Texas.

Occurrence.—White Pine shale at three localities: (1) Pancake Range (locality 4) (figs. 1, 9); (2) Schell Creek Range (locality 2), (figs. 2–4); (3) Snake Range (locality 1), (figs. 5–8). It should also be noted that

Girty (*in* Kirk, 1918, p. 39) identified "Orthoceras, several species" from the White Pine shale, in the Inyo Mountains of southeastern California. Although these specimens have not been available for study, it seems probable that some, if not all of them, are referable to *Mooreoceras*.

Repository.—State Univ. Iowa, 4940 (fig. 1), 4941 (figs. 2, 3), 4942 (fig. 4), 4943 (figs. 5, 6), 4944 (figs. 7, 8), 4945 (fig. 9), and 4946 (large unfigured specimen from Pancake Range).

CYCLOCERAS BALLIANUM Girty
Plate 57, figure 20

Cycloceras ballianum GIRTY, 1909, U. S. Geol. Surv. Bull. 377, pp. 9, 47–48, pl. 6, figs. 15, 15a; MILLER and FURNISH, 1940, Jour. Paleontology, vol. 14, pp. 357, 358, pl. 45, figs. 6, 7.

Although rather poorly preserved, a single individual from the Schell Creek Range appears to be closely similar to a form originally described by Girty from the Caney shale of Oklahoma. This Nevada specimen is 11 mm. in length, and is septate throughout. The conch is essentially circular in cross section, is very gradually expanded orad, and is annulated, with the annulation not quite directly transverse. The annulations are approximately 2 mm. apart from crest to crest. Inasmuch as the specimen seems to have been somewhat distorted during preservation, the slight obliqueness of the annulations to the long axis of the conch may not be significant.

The position of the siphuncle cannot be positively ascertained, but a feature suggestive of that structure is located approximately halfway between the center of the septum and the side assumed to be ventral. It is about 1 mm. in diameter, and in apparent position is comparable to the location of the siphuncle of the holotype of *Cycloceras ballianum*.

It should be added that the specimen under consideration is strikingly similar to the representatives of this species illustrated by Miller and Furnish (1940) from the "Meramec" of Kentucky.

Occurrence.—White Pine shale, Schell Creek Range, Nevada (locality 2). The holotype of the species came from the Caney shale of southeastern Oklahoma. Conspecific specimens are also known from the "Meramec" of Rockcastle County, Kentucky.

Figured specimen.—State Univ. Iowa, 4947.

CYCLOCERAS? sp.
Plate 56, figure 18

A very fragmentary annulated specimen is unique among the nautiloids at hand. Only a portion of the living chamber appears to be preserved, for no traces of the siphuncle or septa are discernible. The conch is essentially circular in cross section and is about 21 mm. in maximum diameter. Parts of three annulations are preserved. These show that they are present both on the external shell and on the internal mold. The annulations are about 5 mm. apart and are considerably narrower than the intervening troughs. The growth lines of the test consist of fine lirae which are distinctly narrower than the adjacent striae. There are between 30 and 40 lirae in the distance from crest to crest of adjacent annulations. The growth lines as well as the annulations are sinuous.

The affinities of this specimen are very uncertain. Superficially, at least, it resembles the form which Hall and Whitfield (1877, p. 278, pl. 6, fig. 15) described as "*Cyrtoceras cessator*." In that species, the conch is said to be "moderately curving throughout its length" and the siphuncle is "submarginal." The holotype came from the White Pine shale in the White Pine Mountains. Although the individual in the present collections is so short that initial curvature (if any) cannot be determined and the siphuncle is not preserved, it may belong to Hall and Whitfield's species, in which case it is not referable to *Mooreoceras*.

It should also be noted that Demanet (1941, p. 117) figured a somewhat similar although straight form from the Namurian of Belgium, and referred it to "*Perigrammoceras sulcatum* (Fleming)."

Occurrence.—White Pine shale, Schell Creek Range, Nevada (locality 2).

Figured specimen.—State Univ. Iowa, 4948.

POTERIOCERAS? spp.
Plate 57, figures 15–19

The adapical portions of what appear to have been two cyrtoceraconic brevicones

have been secured from the White Pine shale. Although the differences in the shape and rate of adoral expansion of the conchs indicate that two species are probably represented, the specimens are so fragmentary that their exact affinities are uncertain. Both are non-testiferous, septate internal molds.

The larger and better preserved of these is some 25 mm. in length. At its adoral end it is about 18½ mm. in maximum width, and the comparable measurement at the adapical end of the preserved portion of the phragmacone is 13 mm. These figures indicate that the conch was expanded orad rather rapidly.

In cross section the conch is subelliptical in outline. The siphuncle is moderate in size at its passage through the septa, and it is decidedly ventrad in position. Each suture is essentially a simple circle and slopes rather strongly adapically from dorsum to venter. The septa are only moderately concave adapically. In the preserved portion of the phragmacone the camerae are slightly less than 3 mm. in length.

The smaller of the two specimens appears to be complete adapically and is much stouter than the form just described. Also, the curvature of the conch is more asymmetrical than the preceding specimen, and the sutures do not slope so strongly ventrad. However, it should be pointed out that only the juvenile portion of this conch is preserved, and the characters elucidated are probably not particularly diagnostic.

The fragmental nature of these individuals makes specific comparisons impractical. A probable representative of *Poterioceras* is also known from the approximately contemporaneous Barnett shale of Texas.

Occurrence.—Both of the specimens came from an outcrop of the White Pine shale in the Snake Range, Nevada (locality 1).

Figured specimens.—State Univ. Iowa, 4949 (figs. 15, 16), 4950 (figs. 17–19).

DISCITOCERAS TEXANUM Miller and Youngquist
Plate 57, figures 10–12

Discitoceras texanum MILLER and YOUNGQUIST, 1948, Jour. Paleontology, vol. 22, p. 654, pl. 94, fig. 6.

An exceptionally fine representative of this species was secured from the upper part of the White Pine shale in the southern portion of the Snake Range. It is septate throughout and most of the test is retained. Somewhat more than a full volution is preserved, and the maximum diameter of the specimen is 19 mm. At the adoral end the height and width of the conch are slightly more than 7 mm. and slightly less than 7 mm., respectively.

The umbilicus is large and perforate, and its maximum diameter is approximately 5 mm. In the adapical portion of the conch the umbilical shoulders are rounded, but they become progressively angular adorally. The adapical portion of the conch is essentially circular in cross section, but with the completion of the first volution the conch is distinctly higher than wide. At this place the cross section of conch is octagonal in shape, although slightly impressed dorsally.

The extreme adapical portion of the test is marked by fine transverse growth lines. Some half a volution orad, this ornamentation gives way to growth lines which form broad rounded lateral saddles and a prominent, somewhat more narrowly rounded, ventral sinus. The testiferous portion of the ventral zone is retuse—each ventro-lateral margin of the test forming a small sharp ridge. Some 2 mm. dorsad of this ridge, another somewhat less prominent ridge is developed on the test. Similar ridges, in more subdued form, are located along the umbilical shoulder of the conch and about 2 mm. ventrad of the umbilical shoulder.

The non-testiferous portion of the specimen shows that the internal mold is only very slightly retuse ventrally, and that it is otherwise devoid of markings such as characterize the test just described. Also, in at least this portion of the phragmacone, the camerae are short and each suture forms a slight saddle as it crosses the umbilical shoulder, a broad, shallow, rounded lateral lobe, and a high flattened ventral saddle. The nature of the internal sutures is unknown, but because of the impressed zone they probably form slight dorsal lobes. The siphuncle is small, at least at its passage through the septa, and is close to the venter in the adoral end of the specimen under consideration.

The holotype of this species has been available for direct comparisons, and, although slightly smaller, the individual from

the White Pine shale agrees in marked detail with the Texas specimen.

Occurrence.—White Pine shale, Snake Range, Nevada (locality 1). Originally described from the Barnett shale about 8 miles southwest of Mason, Texas. Undescribed but probably conspecific specimens in the collections at The State University of Iowa have been secured from the Viséan of the Isle of Man.

Figured specimen.—State Univ. Iowa, 4951.

ENDOLOBUS OCCIDENS Youngquist, n. sp.
Plate 57, figures 13, 14

This species is based on a single specimen collected in the southern portion of the Snake Range. It consists of parts of two volutions. The outer one is non-septate in its ultimate half, and presumably this portion represents living chamber; the inner volution is entirely septate. The total length of the part of the specimen that is preserved is about 29 mm. Tentative reconstruction of this individual indicates that its original diameter was at least 34 mm. The whorls are subelliptical in cross section, being rather broadly rounded ventrally and dorsally, and somewhat more narrowly rounded laterally. There is a very small dorsal impressed zone. The conch is rapidly expanded orad although the ultimate half of the outer volution is somewhat less so. At the adoral end of the outer volution, the conch is about 19 mm. wide and 13 mm. high. Corresponding measurements at the adapical end of the same volution are about 7½ mm. and 6 mm., respectively. The depth of the dorsal impressed zone in the outer whorl is very small —of the order of a millimeter. Ornamentation of the test of the inner volution is reticulate, consisting of rather closely spaced transverse lirae and somewhat more widely separated longitudinal lirae. The test of the outer whorl shows only transverse lirae which have resulted from the rather laminated manner of development of the growth increments. These growth lines incline gently apicad from the umbilicus to the point where they cross the narrowly rounded lateral zone of the conch. At this place they incline strongly apicad and form a rather large, deep, narrowly rounded ventral sinus.

The narrow ventrolateral zones of the conch bear very small but distinct nodes. The umbilicus is presumably perforate, for the dorsal portion of the inner volution of the conch is not impressed.

This species appears to be somewhat intermediate between typical *Liroceras* and *Endolobus*. However, the presence of small nodes on the lateral zones of the conch places it with reasonable certainty in the latter genus. It differs from *E. ornatus* Girty, with which it occurs in direct association, in the greater development of the ventral sinus, the smaller nodes, the lack of reticulate ornamentation on the larger portions of the holotype, and the more nearly circular cross section of the whorls.

Occurrence.—White Pine shale, Snake Range, Nevada (locality 1).

Holotype.—State Univ. Iowa, 4952.

ENDOLOBUS ORNATUS Girty
Plate 58, figures 12–17

Endolobus ornatus GIRTY, 1911, U. S. Geol. Surv. Bull. 439, pp. 19, 22, 95–96, pl. 13, figs., 2–2b; CRONEIS, 1930, Arkansas Geol. Surv. Bull. 3, pp. 55, 71; MILLER, DUNBAR, and CONDRA, 1933, Nebraska Geol. Surv., Bull. 9, 2nd ser., p. 194; GORDON, 1944, Am. Assoc. Petroleum Geol., Bull., vol. 28, p. 1630.

(?) *Endolobus ornatus* CRONEIS?, 1930, Arkansas Geol. Surv., Bull. 3, p. 71.

Two specimens in the collections under consideration appear to be clearly referable to the species first described by Girty from the Moorefield shale of Arkansas. His holotype was fragmentary, but nevertheless, the essential characteristics of this form were well elucidated by the original illustrations, and Girty's description applies to the two Nevada specimens with very minor differences. Although the original diagnosis states that the "siphuncle is large," the illustrations suggest that this structure may be moderate in size and the Nevada specimens bear out this observation.

The better preserved of these two specimens is about 18½ mm. in maximum diameter and is septate throughout. In cross section the conch is more or less reniform in shape, being depressed dorsoventrally, somewhat narrowly rounded laterally, and slightly impressed dorsally. Also, there is a very shallow longitudinal groove along the venter.

At the adoral end of the outer volution,

the conch is approximately 8 mm. high and 12 mm. wide. Corresponding measurements near the adapical end of the outer volution are slightly less than 4 mm. and slightly more than 4 mm., respectively, indicating that the conch expands orad fairly rapidly and that the immature portions of the conch tend to be circular or nearly so in cross section.

The test bears reticulate ornamentation. Rather prominent longitudinal lirae are present, and there are some 20 of these small ridges across the venter between the umbilical shoulders. Relatively fine transverse growth lines form a deep narrowly rounded ventral sinus, a very slight salient across the umbilical shoulder, and a small sinus on the umbilical wall. Presumably the deep ventral sinus of the growth increments indicates the initial presence of a prominent hyponomic sinus. It should be added that traces of the transverse growth lines are present on the internal mold, but no evidences of the longitudinal lirae are visible.

The umbilical shoulders are narrow and nodose. There are about 14 nodes on the outer volution of the specimen illustrated by figures 12–15 on plate 58. These nodes are not prominently developed on the ventral side of the umbilical shoulders, but on the umbilical walls they persist as small transversely elongate ridges. The umbilical walls are broadly rounded and the test of this portion of the conch bears both lirae and growth lines, as do other parts of the conch. The umbilicus is most probably perforate.

Each external suture forms a small shallow ventral lobe and a broadly rounded, very low ventral saddle. The sutures appear to be essentially straight across the umbilical shoulder and wall. The nature of the internal sutures is unknown, but the presence of a dorsal lobe is probable, due to the impressed zone. The siphuncle is not large, at least at its passage through the septa, being hardly a millimeter in diameter in the adoral septum of the better of the specimens under consideration.

The poorer of these two specimens is 19 mm. in maximum diameter. In the main, it is only an internal mold which appears to be septate throughout and is preserved in limonitic limestone of a friable nature. In all discernible characters, however, it is essentially identical with the better specimen just described. The two are almost certainly conspecific, and both agree in detail with the fragmentary but well described and illustrated individual from the Moorefield of Arkansas.

Occurrence.—White Pine shale, Snake Range (locality 1), Nevada (figs. 12–15); and the same formation in the Schell Creek Range (locality 2), (figs. 16, 17). Originally described from the Moorefield shale of Arkansas. Croneis (1930) also records *Endolobus ornatus* from the "lower limestone" of the Fayetteville formation of Arkansas, and *E. ornatus?* from the Wedington sandstone member of the Fayetteville of the same state.

Figured specimens.—State Univ. of Iowa, 4953 (figs. 12–15), 4954 (figs. 16, 17).

EXPLANATION OF PLATE 58

All specimens illustrated on this plate are from the White Pine shale of east-central Nevada.

FIGS. *1–3—Eumorphoceras plummeri* Miller and Youngquist. Three views of a well-preserved specimen from the southern portion of the Snake Range, White Pine County, ×2. (p. 301)

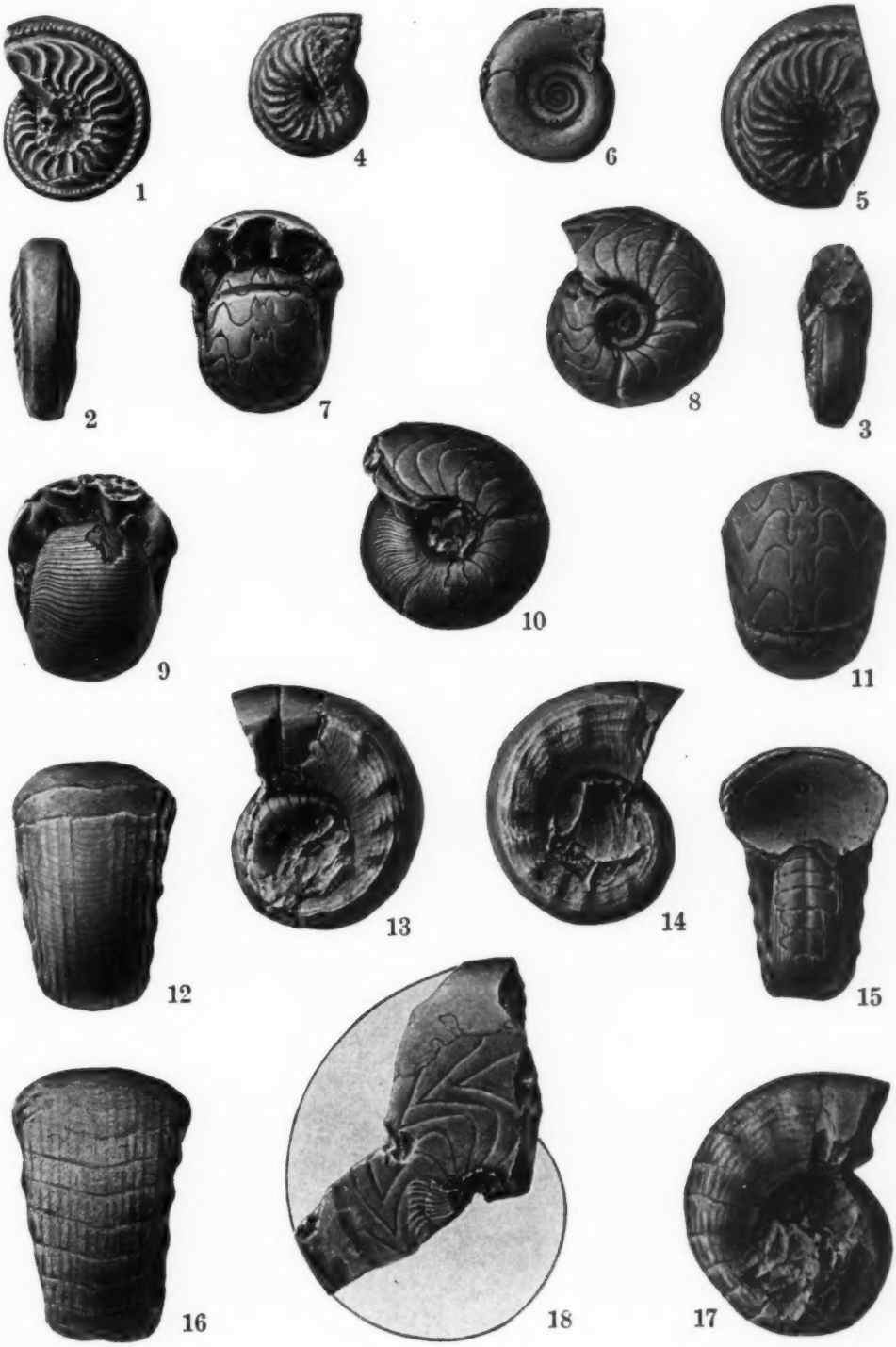
4, 5—Eumorphoceras bisulcatum Girty. Figure *4*, a somewhat larger but fragmentary specimen, ×1½; both from the southern portion of the Snake Range, White Pine County. (p. 299)

6—Epicanites? sp. Lateral view of a specimen from the central portion of the Schell Creek Range, .7 mile west of Connor's Pass, White Pine County, ×2. (p. 303)

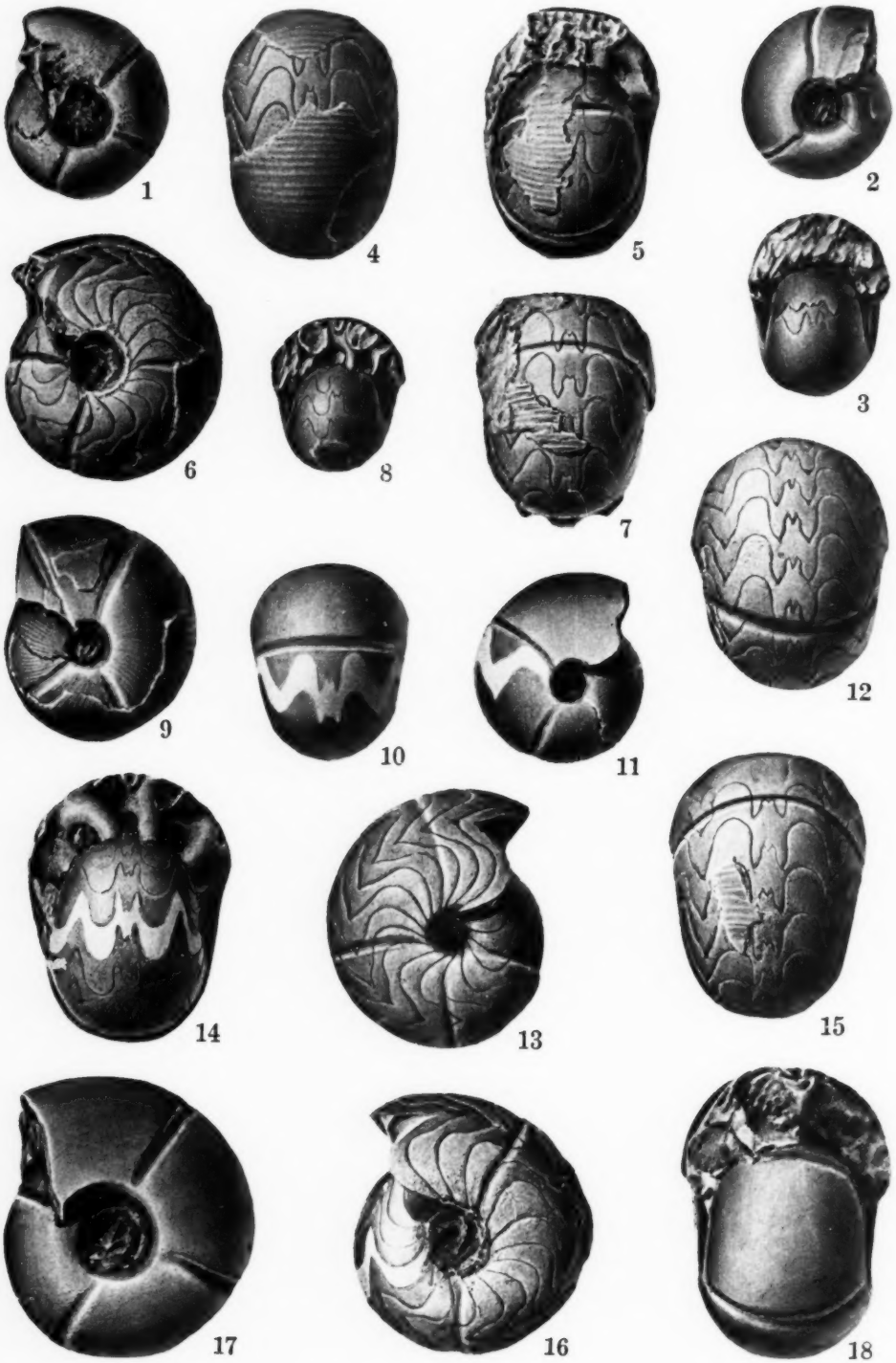
7–11—Cravenoceras nevadense Miller and Furnish. Two well-preserved septate individuals. Figures *7*, *8*, from the southern portion of the Snake Range, White Pine County, ×2; figures *9–11*, from an eastern spur of the Pancake Range, Nye County, ×2. (p. 295)

12–17—Endolobus ornatus Girty. Figures *12–15* represent a single specimen from the southern portion of the Snake Range, ×2. Figures *16*, *17*, illustrate a specimen from the central portion of the Schell Creek Range, .7 mile west of Connor's Pass, White Pine County, ×2. (p. 287)

18—Girtyoceras meslerianum (Girty). A large but fragmentary individual from an eastern spur of the Pancake Range, about 5 miles north of Duckwater, Nye County, ×1. (p. 302)



Youngquist, Nevada Mississippian Cephalopods



Youngquist, Nevada Mississippian Cephalopods

LIROCERAS spp.
Plate 57, figures 1–9

Two well-preserved representatives of *Liroceras* were collected from widely separated localities in the White Pine shale of eastern Nevada. Although they are both too small and immature for satisfactory study, each nevertheless appears to represent a distinct species. Both are internal molds and are septate throughout. One retains small portions of the test.

The specimen illustrated by figures 1–4 is about 19 mm. in diameter. Its whorls are moderately compressed dorso-ventrally, and narrowly rounded laterally. The dorsal zone is impressed. At the adoral end, the conch is about 15½ mm. wide and 9½ mm. high. The depth of the impressed zone is approximately a millimeter. The siphuncle is located slightly ventrad of median and is small, at least at its passage through the septa. Faint traces of the growth lines on the more nearly mature portions of the conch indicate that they were transverse, although forming a rather deep ventral sinus. The earlier portions of the conch apparently bore reticulate ornamentation. A small narrow median longitudinal groove is present on the venter of the internal mold. The sutures are straight and essentially transverse, and the camerae are moderate in length.

The other specimen in most features agrees with the form just described. However, at an equal diameter. the conch is distinctly higher and narrower in the latter form, and the septa are not so concave.

Occurrence.—The White Pine shale, Snake Range (locality 1), (figs. 1–4); and the same formation in the Pancake Range (locality 4), (figs. 5–9).

Figured specimens.—State Univ. Iowa, 4955 (figs. 1–4), and 4956 (figs. 5–9).

BACTRITES NEVADENSE
Youngquist, n. sp.
Plate 56, figures 12–15

The collections under consideration contain four specimens referable to *Bactrites*. All of them represent portions of the phragmacone; none retains the living chamber or any traces of the test ornamentation. They were collected at a single locality in the southern part of the Snake Range. All appear to be conspecific and apparently represent an undescribed species. The conch is gradually expanded orad, and is elliptical in cross section, being somewhat compressed laterally and rather narrowly rounded both dorsally and ventrally. The largest of these individuals (figs. 12, 13) is 29 mm. in length. The greater diameter of the adapical end of the conch is 14 mm., the lesser diameter is 11 mm. Corresponding measurements at the adoral end of the specimen are approximately 18 mm. and 15 mm., respectively. The camerae are relatively short, there being about three in a length of 8 mm. Each suture forms a broad, broadly rounded lateral lobe, and low, somewhat more narrowly rounded dorsal and ventral saddles. The siphuncle is small and is marginal in position.

The unfigured specimens are slightly

EXPLANATION OF PLATE 59

All specimen illustrated on this plate are from the White Pine shale of east-central Nevada.

FIGS. *1–3*—*Cravenoceras nevadense* Miller and Furnish. Figure *1*, an average-sized specimen from the east-central portion of the Egan Range, White Pine County, ×1; figures *2*, *3*, one of the syntypes (after Miller and Furnish) from the southern portion of the Snake Range, White Pine County, ×2½. (p. 295)

4–16—*Cravenoceras hesperium* Miller and Furnish. Figures *4–6*, a specimen retaining portions of the test, from the central part of the Schell Creek Range, .7 mile west of Connor's Pass, White Pine County, ×1½; figure *7*, a fragmentary individual from the same horizon and locality as preceding, ×1½; figures *8–11*, three of the syntypes of the species (after Miller and Furnish), figure *8* is ×2½, figure *9* is ×1, the specimen represented by figures *10*, *11*, is ×1½, all from the east-central portion of the Egan Range, White Pine County; figures *12*, *13*, a completely septate individual from an eastern spur of the Pancake Range, about 5 miles north of Duckwater, Nye County, ×1½; figures *14–16*, a well-preserved specimen from the same horizon and locality as the preceding, ×2. (p. 291)

17, *18*—*Cravenoceras nevadense* Miller and Furnish. A well-preserved specimen from the central portion of the Schell Creek Range, .7 mile west of Connor's Pass, White Pine County, ×1½. (p. 295)

smaller than the figured specimens but possess the characteristics just described. All of them represent portions of the phragmacone; none retain the living chamber or any traces of the test ornamentation. This species seems to differ from other representatives of the genus from similar horizons (*e.g., Bactrites? quadrilineatus* Girty from the Caney shale of Oklahoma) in the laterally compressed nature of the conch and in the shape of the sutures.

Occurrence.—White Pine shale, Snake Range, Nevada (locality 1).

Types.—State Univ. Iowa, 4957 (holotype, figs. 12, 13), 4958 (paratype, figs. 14, 15), and 4959, 4960 (2 unfigured paratypes).

Genus CRAVENOCERAS Bisat, 1928

Cravenoceras is the most abundant single generic unit in the collections under consideration, some 2900 to 3000 individuals being available for study. With such a large amount of material the classification of these specimens is indeed difficult. However, the great majority of them can be placed in either *Cravenoceras hesperium* or *C. nevadense* both of Miller and Furnish. *C. scotti* Miller and Youngquist is also represented. In general, these three species are delimited in the following manner: (1) *Cravenoceras hesperium* has a globular conch and a small umbilicus. In some cases the ventral lobe of the suture is broader than in *C. nevadense*, but this is not always true. (2) *C. nevadense* has a relatively high, narrow conch and a wide umbilicus. Commonly the ventral lobe of the suture is narrower than in *C. hesperium*. (3) *C. scotti* has a rotund, subglobular conch, whorls which are much depressed dorso-ventrally and a relatively large umbilicus. (4) A fourth category is needed for specimens in the collections at hand which have a high, narrowly rounded conch, a small umbilicus, and a suture with evenly rounded first lateral saddles and a rather wide ventral lobe. For this form, a new species, *C. merriami*, is proposed.

All of these species have sutures which appear to be typical of *Cravenoceras*. That is, the ventral lobe is relatively straight sided, and is divided by a small secondary saddle which itself is bifid. The first lateral saddle is rounded, the first lateral lobe is acuminate, the second lateral saddle is asymmetrically rounded and extends to the umbilical shoulder. Just inside the umbilical shoulder on the steep umbilical wall, there is a small narrow lobe. The growth lines, although slightly sinuous, are nearly straight and directly transverse and they closely parallel the constrictions. These constrictions number about three or four on each volution of the internal mold and result from an internal ridge-like thickneing of the test. They do not appear on the outer surface of the test (*e.g.*, pl. 59, fig. 9, and pl. 60, fig. 11) although their presence can sometimes be detected by a slight subduing of the growth lines over the position of the constriction or a small adoral or adapical displacement of the growth lines relative to their normal position.

It should be emphasized that with the large number of specimens in these collections, gradations among all four of the aforementioned species exist, *C. merriami* being relatively the most nearly stable entity. It may be that the specific names should be relegated to varietal status, and *Cravenoceras kingii* (Hall and Whitfield) which has priority, should be considered the single species, although from the published illustrations, *C. kingii* appears to be quite distinct.

Finally, the general resemblance of *Cravenoceras* to *Goniatites s. s.* should be noted. Since the physiognomies of certain representatives of both genera are very similar, sutures appear to offer the best method of differentiating these two forms. That is, the first lateral saddle of the mature suture of *Cravenoceras* is rounded, whereas the same element in *Goniatites* is more or less acuminate. In addition, the saddle which divides the ventral lobe is in general much larger and higher in *Goniatites s. s.* than in *Cravenoceras*. The similarity in shape of conch but difference in shape of the sutures of representatives of these two genera is illustrated by comparing figure 4 (*Cravenoceras*) with figure 7 (*Goniatites*) on plate 62. Also, representatives of *Goniatites* commonly appear to have a much smaller umbilicus than do such *Cravenoceras* species as *C. scotti* and *C. nevadense*. However, some specimens of *C. hesperium* have very small umbilici, and *C. merriami* is very similar in this

respect to *Goniatites s. s.* (*cf.* figs. 6 and 10 on plate 63).

CRAVENOCERAS HESPERIUM
Miller and Furnish

Plate 59, figures 4–16; plate 60, figures 1,2, 8–15; plate 61, figures 1–3, 10–12; plate 62, figures 1–6, 16–18.

Nuculoceras incisum [part] PLUMMER and SCOTT, 1937, Texas Univ. Bull. 3701, pp. 15, 29, 30, 33, 106–108, 109, 113, 383, 384, 399, pl. 7, figs. 7–9, 11–14 [not 10].

Nuculoceras barnettense [part?] PLUMMER and SCOTT, 1937, Texas Univ. Bull. 3701, pp. 15, 33, 106, 108–109, 110, pl. 7, figs. 15–18.

Cravenoceras hesperium MILLER and FURNISH, 1940, Jour. Paleontology, vol. 14, pp. 356, 373, 374–375, pl. 49, figs. 1–8.

?Cravenoceras hesperium MILLER and YOUNGQUIST, 1948, Jour. Paleontology, vol. 22, p. 656, pl. 95, figs. 7–9, 13–15.

The syntypes of this species came from the White Pine shale in the east-central portion of the Egan Range, near the boundary between Lincoln and White Pine counties, and were originally described by Miller and Furnish. The additional material now available from the same formation at other localities in eastern Nevada indicates that *C. hesperium* is abundant. The largest of the illustrated specimens (pl. 60, figs. 13–15) is slightly more than 28 mm. in diameter. Near the adoral end of the outer volution the conch is about 22 mm. wide and 12 mm. high. The umbilicus is lightly less than a fourth the total diameter of the specimen, being a little more than 5 mm. wide. This specimen is almost entirely testiferous but a small break in the shell (pl. 60, fig. 14) indicates that at least the adapical half of the outer volution is nonseptate and presumably therefore represents living chamber. The growth lines are relatively fine and sinuous. Each line forms a broad, low ventral saddle, a small, shallow dorso-lateral lobe, and a slight saddle in the vicinity of the umbilical shoulder. This test ornamentation appears to be characteristic of the species and in some cases has been impressed on the internal mold (*e. g.*, pl. 62, figs. 1–3 and 16–18).

All of the internal molds of this species now available for study show constrictions which vary in number from about three to five per volution. The sutures are typical of *Cravenoceras*, although the tendency of some of the first lateral saddles to become club-shaped, *i. e.*, constricted near midlength (see pl. 60, fig. 5, and pl. 62, figs. 16, 18) is noteworthy. However, this feature is definitely gradational among the many specimens available for study and does not seem to be significant. Fragmentary individuals not illustrated indicate that this species attained a diameter of at least 35 mm.

Occurrence.—Abundant at the following four localities in the White Pine shale of east-central Nevada: (1) Schell Creek Range (locality 2), (pl. 59, figs. 4–7; pl. 62, figs. 1–3) (2) Egan Range (locality 3), (syntypes, from Miller and Furnish, pl. 59, figs. 8–11); (3) Pancake Range (locality 4), (pl. 59, figs. 12–16; pl. 60, figs. 8–12; pl. 61, figs. 1–3, 10–12; pl 62, figs. 4–6, 16–18; and (4) Snake Range (locality 1) (pl. 60, figs. 1, 2, 13–15). Specimens which are probably conspecific have been reported from several localities in the Barnett formation of Texas.

Figured specimens.—State Univ. Iowa, 4961 (pl. 59, figs. 4–6), 4962 (pl. 59, fig. 7), 4963 (pl. 59, figs. 12, 13), 4964 (pl. 59 figs. 14–16), 4965 (pl. 60, figs. 1, 2), 4966 (pl. 60, figs. 8–10), 4967 (pl. 60, fig. 11), 4968 (pl. 60, fig. 12), 4969 (pl. 60, figs. 13–15), 4970 (pl. 61, figs. 1–3), 4971 (pl. 61, figs. 10–12), 4972 (pl. 62, figs. 1–3), 4973 (pl. 62, figs. 4–6), and 4974 (pl. 62, figs. 16–18). Specimens illustrated by figures 8–11 on plate 59 are in the collections at the U. S. National Museum.

CRAVENOCERAS MERRIAMI
Youngquist, n. sp.
Plate 61, figures 4–7; plate 63, figures 9–12

Conch relatively high, compressed laterally, rounded ventrally and deeply impressed dorsally. The umbilicus is small. The umbilical shoulders are rounded but abrupt and the umbilical walls are essentially normal to the flattened lateral zones of the conch. The test is marked by fine transverse lines which result from the lamellar growth of the shell. That is, the test appears to have grown by small transverse increments, each of which is a millimeter or so in width (in the more nearly mature portions of the conch) and terminates adorally in a small

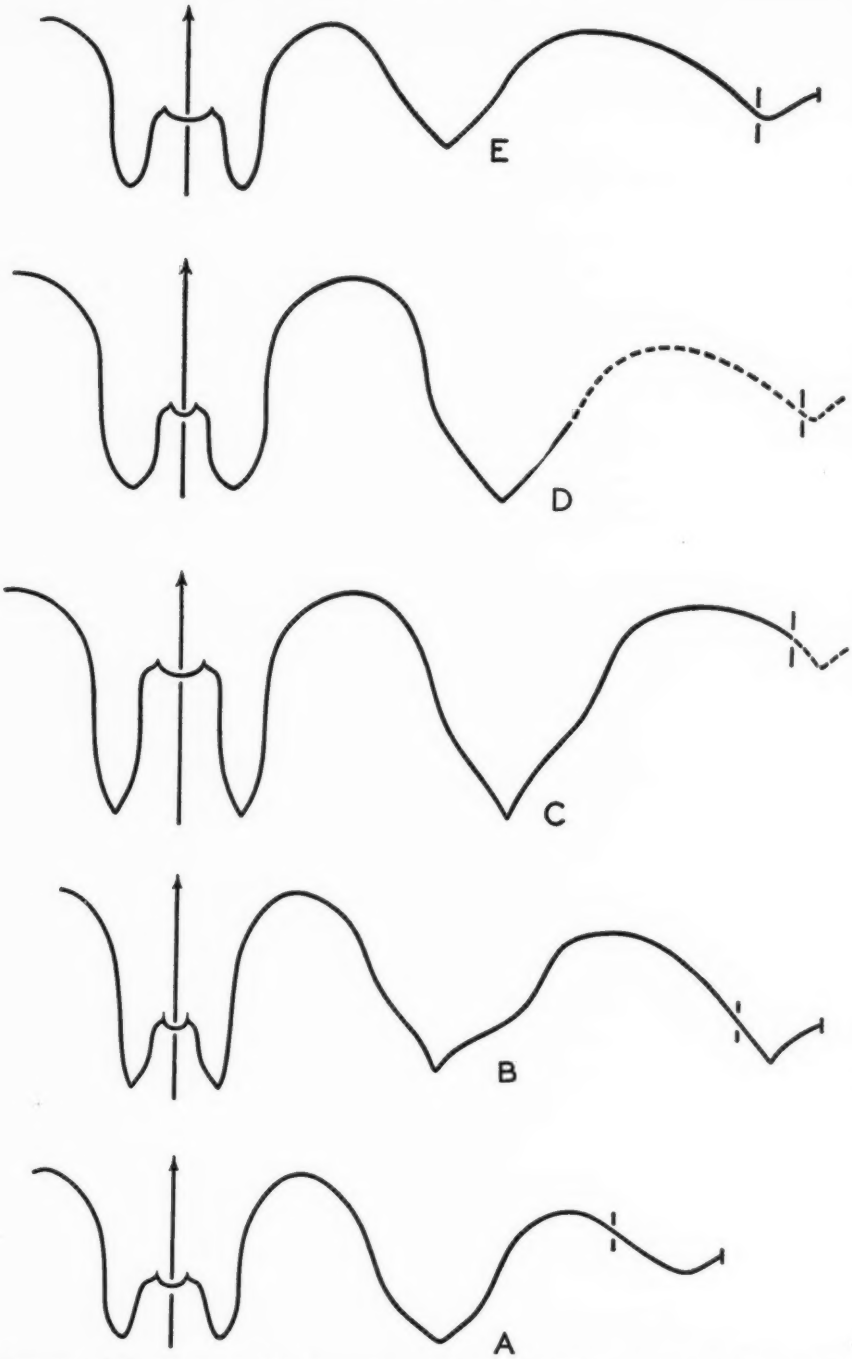


FIG. *1*—Sutures of *Cravenoceras*. (A) *Cravenoceras nevadense* Miller and Furnish from the White Pine shale in the Snake Range of Nevada, at a diameter of about 7 mm., ×14, (from Miller and Furnish). (B) *Cravenoceras hesperium* Miller and Furnish from the White Pine Shale in the Egan Range (Cave Valley area) of Nevada at a diameter of about 17 mm., ×7, (from Miller and Furnish).

but steep edge which is the "line" of growth. As in other representatives of *Cravenoceras*, these growth lines do not indicate the initial presence of a deep hyponomic sinus. Rather they form a very broad but very slight ventral sinus and a small indistinct sinus just ventrad of the umbilical shoulder.

Constrictions are prominently developed on the internal molds of at least the mature representatives of this species. They are evidently the result of an internal thickening of the test and their presence is not usually indicated externally. There are from about five to seven constrictions per volution. They are relatively broad and are asymmetrical—that is, the constrictions are gradually impressed on their adapical sides but have a steep side and are deeply impressed along their adoral margins (*e. g.*, pl. 63, fig. 10).

The mature sutures (text fig. 1C) form a deep, straight-sided ventral lobe which is divided by a very high (for this genus) straight-sided saddle. This saddle is distinctly but not prominently bifid. The first lateral saddle is asymmetrically U-shaped and is rounded. It is followed by a lateral lobe which is broad but acuminate. The second lateral saddle is high, rather steep-sided, and extends to the umbilical shoulder. The immature sutures, at a diameter of about 8½ mm., (text fig. 1D) are for the most part similar to the more nearly mature form at 22 mm. diameter (text fig. 1C) except that the saddle in the ventral lobe of the former is much less developed.

The diameter of the largest of the figured specimens (pl. 63, fig. 12), which came from an eastern spur of the Pancake Range, is slightly more than 52 mm. The umbilicus is approximately 9 mm. in diameter. The outer volution of this specimen is entirely non-septate and presumably therefore represents living chamber. Near the adoral end of the ultimate whorl the conch is about 27 mm. high and 27 mm. wide. Corresponding measurements near the adapical end of the same volution are about 18½ mm. and 22 mm., respectively, indicating a progressive heightening of conch adorally and suggesting that even this rather large specimen may not be entirely mature. There are at least six constrictions on the outer whorl of this individual. Another well preserved specimen (pl. 63. fig. 9) secured from the Schell Creek Range is 41 mm. in diameter, and the umbilicus is about 7½ mm. wide. Near the adoral end of the outer volution the conch is about 22 mm. wide and 20 mm. high. This whorl retains impressions of at least six constrictions, and a suggestion of a seventh is present on the extreme adoral portion. The species is of common occurrence in the White Pine shale and fragmentary specimens indicate that it attained a diameter of more than 60 mm. For reasons not apparent, the majority of them retain a large portion of the living chamber, (most of the goniatites in the collections do not), and these individuals indicate that this structure was at least a full volution in length.

Although *C. merriami* is represented by some 50 individuals in the collections at hand, its form is strikingly constant as compared with other species of *Cravenoceras*. From the specimens available, it appears that *C. merriami* is a comparatively stable and easily recognized entity.

Among the described species of *Cravenoceras*, *C. merriami* appears to be closest to *C. richardsonianum* (Girty) of the Caney shale of Oklahoma. For comparative purposes, two specimens of the latter species from the Caney are illustrated in the present report. *C. merriami* differs from *C. richardsonianum* in that the mature sutures of the former have a somewhat narrower and more

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(C) *Cravenoceras merriami* Youngquist, n. sp., from the White Pine shale in an eastern spur of the Pancake Range of Nevada. A mature suture based on the specimen illustrated by figure 4 on plate 61, at an estimated diameter of about 22 mm., ×6. (D) Immature suture of *Cravenoceras merriami*, n. sp. from the White Pine shale in an eastern spur of the Pancake Range of Nevada, based on the specimen illustrated by figure 7 on plate 61, ×12, which is an early portion of the conch of the specimen illustrated by figure 5 on the same plate, at a diameter of about 8½ mm. (E) *Cravenoceras richardsonianum* (Girty) from the Caney shale of Oklahoma, based on the specimen illustrated by figures 8, 9 on plate 61, at a diameter of about 46 mm., ×3½.

nearly straight-sided ventral lobe which is in turn divided by a secondary saddle that is longer and narrower and also has straighter sides than does the corresponding feature in *C. richardsonianum*. Also, the ventral lobe, the first lateral saddle, and the first lateral lobe of *C. merriami* are longer than

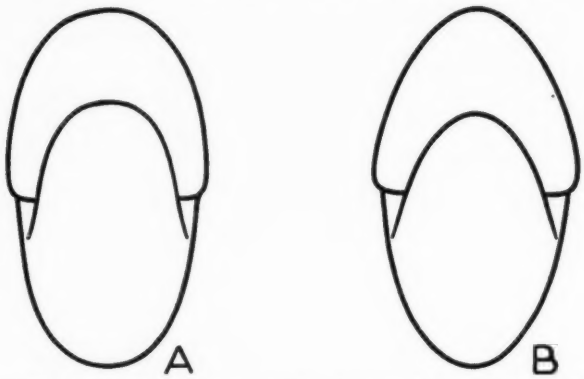


FIG. 2—Outlines in profile of (A) *Cravenoceras merriami*, n. sp. from the White Pine shale of Nevada, and (B) *C. richardsonianum* (Girty) from the Caney shale of Oklahoma, both ×1.

are those of *C. richardsonianum* (see text figs. 1C, E for comparisons). In general, the mature suture of *C. merriami* is more advanced than that of *C. richardsonianum*. That is, the sutures of *C. merriami* pass through the *C. richardsonianum* stage comparatively early in ontogenetic development. Text figure 1D of an immature suture of *C. merriami* at a diameter of only some 8½ mm. is nevertheless somewhat further advanced than is the mature suture of *C. richardsonianum* at a conch diameter of about 46 mm. shown by text figure 1E. Perhaps the most readily recognizable distinction, however, is in the shape of the conch in these two species. These are compared in text figure 2. It can be seen that *C. richardsonianum* has a more narrowly rounded conch than does *C. merriami*. A number of specimens of *C. richardsonianum* from the Caney shale in Pontotoc County, Oklahoma, have been available for study. In all of them, the very narrowly rounded venter (which is particularly well shown by Girty's type, 1909, pl. 11, fig. 1a) readily differentiates them from the numerous specimens of *C. merriami* under consideration.

The specific name is given in honor of Dr. Charles W. Merriam who collected the first known representatives of this form, and called attention to the occurrence of an abundant ammonoid fauna in the White Pine shale of the Pancake Range area.

All of the representatives of *C. richard-*

EXPLANATION OF PLATE 60

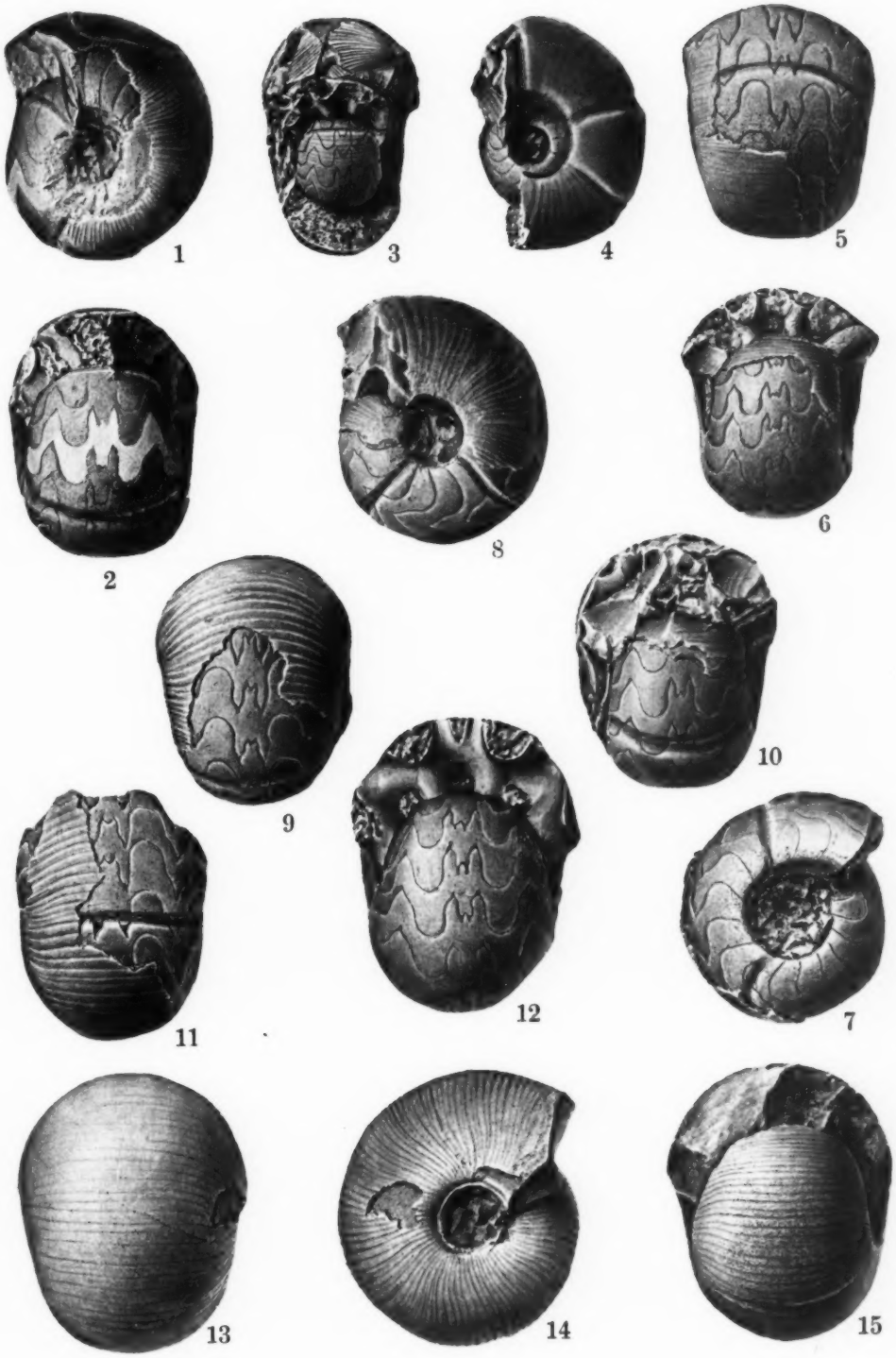
The specimens illustrated on this plate are from the White Pine shale at two localities in east-central Nevada. Those represented by figures *1*, *2*, and *13–15* are from an outcrop in the southern portion of the Snake Range, White Pine County. All others are from a shale exposure in an eastern spur of the Pancake Range, about 5 miles north of Duckwater, Nye County.

FIGS. *1*, *2*—*Cravenoceras hesperium* Miller and Furnish. A completely septate specimen, ×1½. (p. 291)

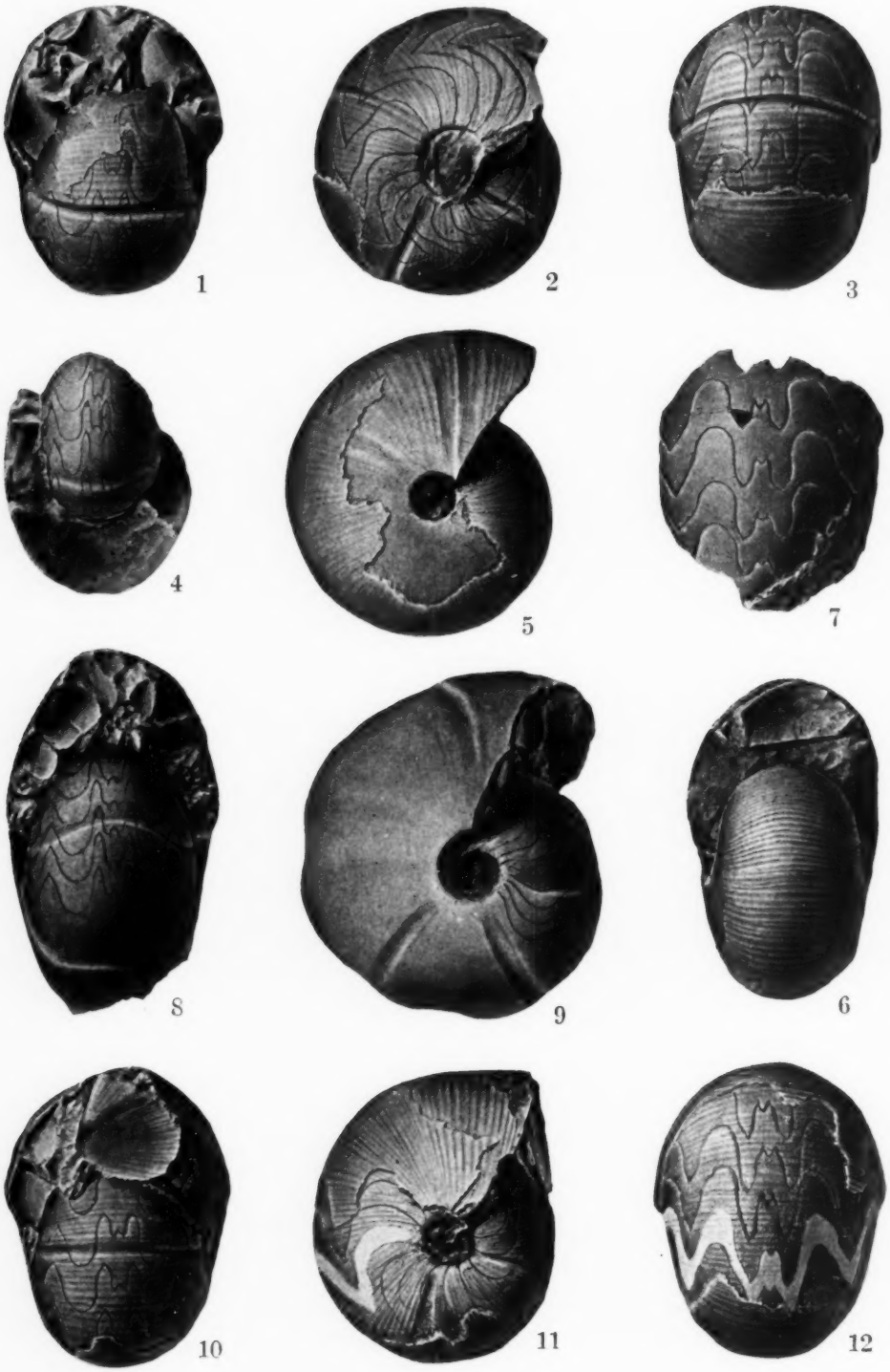
3, *4*—*Cravenoceras nevadense* Miller and Furnish. A fragmentary specimen showing part of the living chamber and septate inner volutions. ×1. (p. 295)

5–7—*Cravenoceras scotti* Miller and Youngquist. Three views of a well-preserved specimen showing sutures and test, ×2. (p. 296)

8–15—*Cravenoceras hesperium* Miller and Furnish. Figures *8–10*, a small individual, ×2; figure *11*, incomplete individual with sutures having somewhat constricted first lateral saddles, ×1½; figure *12*, part of a phragmacone, ×2; *13–15*, a rotund testiferous specimen, ×1½. (p. 291)



Youngquist, Nevada Mississippian Cephalopods



Youngquist, Nevada Mississippian Cephalopods

sonianum figured in the present report were collected by Mr. John M. Ware from the Caney shale about ½ mile northwest of Frisco, Oklahoma; that is, in the NW¼ Sec. 8, T. 2 N., R. 7 E., Pontotoc County. These specimens are in the repository of the Geology Department of The State University of Iowa.

Occurrence.—The White Pine shale at three localities: (1) Pancake Range (locality 4), (pl. 61, figs. 4–7; pl. 63, figs. 10-12); (2) Schell Creek Range (locality 2), (pl. 63, fig. 9); and (3) Snake Range (locality 1), (numerous unfigured specimens).

Syntypes.—State Univ. Iowa, 4975 (pl. 61, fig. 4), 4976 (pl. 61, figs. 5–7), 4977 (pl. 63, fig. 9), 4978 (pl. 63, figs. 10, 11), and 4979 (pl. 63, fig. 12).

CRAVENOCERAS NEVADENSE
Miller and Furnish

Plate 58, figures 7–11; plate 59, figures 1–3, 17, 18; plate 60, figures 3, 4; plate 62, figures 11–15; plate 64, figures 13–16.

Nuculoceras incisum [part?] PLUMMER and SCOTT, 1937, Texas Univ. Bull. 3701, pp. 15, 29, 30, 33, 106–108, 109, 113, 383, 384, 399 [not pl. 7, figs. 7–14]; [part?] CLOUD and BARNES, Texas Univ. Bull. (in press).

Nuculoceras barnettense [part?] PLUMMER and SCOTT, 1937, Texas Univ. Bull. 3701, pp. 15, 33, 106, 108–109, 110, [not pl. 7, figs. 15–18]; [part?] CLOUD and BARNES, Texas Univ. Bull. 4621 (1948).

Cravenoceras richardsonianum [part] PLUMMER and SCOTT, 1937, Texas Univ. Bull. 3701, pp. 15, 116, 261–262, 265, 379, 380, 383, 384, 399, pl. 8, figs. 12–16; [part?] CLOUD and BARNES, Texas Univ. Bull. (in press).

Cravenoceras? nevadense MILLER and FURNISH, 1940, Jour. Paleontology, vol. 14, pp. 356, 373, 374, 375–376, pl. 49, figs. 9–13.

Cravenoceras nevadense MILLER and YOUNGQUIST, 1948, Jour. Paleontology, vol. 22, p. 657, pl. 95, figs. 4–6, 10–12, pl. 96, figs. 4–6, 13–15; pl. 100, figs. 18, 19.

A number of specimens in the present collections exhibit rather large umbilici, subglobular to somewhat narrow conchs, and transverse test ornamentation which are characteristic of *Cravenoceras nevadense.* Although closely related to, and apparently more or less gradational with *C. hesperium* Miller and Furnish, *C. nevadense* has a somewhat higher and narrower conch and a larger umbilicus. In the present collections, this species is perhaps best typified by the two individuals represented by plate 59, figures 17, 18, and plate 60, figures 3, 4, respectively. The former specimen has a maximum diameter of 28½ mm. Its outer volution of conch is entirely non-separate and presumably therefore represents living chamber. At the adoral end, its height of conch is 12½ mm., and its width is about 19 mm. The umbilicus is slightly less than 9 mm. in diameter—not quite a third the diameter of the specimen. Four essentially straight and directly transverse narrow constrictions are preserved on the outer whorl. Traces of the growth lines impressed on the internal mold show that they more or less parallel the constrictions.

Part of the septate inner volutions as well as a portion of the living chamber are preserved on the fragmentary specimen illustrated by figures 3 and 4 on plate 60. The diameter of this specimen was at least 33½ mm. The umbilicus is somewhat more than 11 mm. wide. Height and width of conch at the adoral end of the preserved portion are 14 mm. and 22 mm., respectively.

Occurrence.—Common in the White Pine

EXPLANATION OF PLATE 61

With the exception of figures *8* and *9*, all specimens illustrated on this plate are from an outcrop of the White Pine shale in an eastern spur of the Pancake Range, about 5 miles north of Duckwater, Nye County, Nevada. The individual represented by figures *8*, *9*, is from the Caney shale of Pontotoc County, Oklahoma.

FIGS. *1–3*—*Cravenoceras hesperium* Miller and Furnish. Three views of a well-preserved septate individual, ×2. (p. 291)

4–7—*Cravenoceras merriami* Youngquist, n. sp. Figure *4*, a fragmental syntype, ×1; figures *5*, *6*, lateral and apertural views of a syntype retaining part of the living chamber, ×1½; and, figure *7*, a septate portion of an inner volution of the conch of the specimen illustrated by figures *5* and *6*, ×4. (p. 291)

8, *9*—*Cravenoceras richardsonianum* (Girty). A large well-preserved specimen, ×1. (p. 293)

10–12—*Cravenoceras hesperium* Miller and Furnish. An average-sized specimen retaining portions of the test, ×2. (p. 291)

shale at four localities: (1) Snake Range (locality 1), (pl. 58, figs. 7, 8; pl. 59, figs. 2. 3—two of the syntypes, after Miller and Furnish); (2) Pancake Range (locality 4), (pl. 58, figs. 9–11; pl. 60, figs. 3, 4; pl. 62, figs. 13–15; pl. 64, figs. 15, 16); (3) Egan Range (locality 3), (pl. 59, fig. 1); and (4) Schell Creek Range (locality 2), (pl. 59, figs. 17, 18; pl. 62, figs. 11, 12; pl. 64, figs. 13, 14).

Conspecific specimens are also well represented in collections from the Barnett shale at several localities in central Texas.

Figured specimens.—State Univ. Iowa, 4980 (pl. 58, figs. 7, 8), 4981 (pl. 58, figs. 9–11), 4982 (pl. 59, fig. 1), 4983 (pl. 59, figs. 17, 18), 4984 (pl. 60, figs. 3, 4), 4985 (pl. 62, figs. 11, 12), 4986 (pl. 62, figs. 13–15), 4987 (pl. 64, figs. 13, 14), and 4988 (pl. 64, figs. 15, 16). The specimens illustrated by figures 2 and 3 on plate 4 are two of the syntypes of the species and are in the U. S. National Museum.

CRAVENOCERAS SCOTTI MILLER and Youngquist
Plate 60, figures 5–7

Cravenoceras scotti MILLER and YOUNGQUIST, 1948, Jour. Paleontology, vol. 22, pp. 657–658, pl. 96, figs. 7, 8; pl. 97, figs. 22–24.

A single representative of this species has been secured from the Pancake Range of Nevada. It is a completely septate obese individual with a diameter of about 17 mm. The whorls are wide and considerably depressed dorsoventrally. At the adoral end of the specimen the width and height of conch are 14 mm. and 5 mm., respectively. Corresponding measurements near the adapical end of the same volution are 9 mm. and 4 mm., indicating a rapid expansion of the conch and suggesting that the individual is immature. The umbilicus has a maximum diameter of about 6½mm. Small portions of the test are retained and the growth lines are similar to those described on *C. hesperium*. Direct comparison of this specimen with the holotype shows that the two are strikingly similar.

Occurrence.—The White Pine shale, Pancake Range, (locality 4). The types of the species came from the Barnett shale at a single locality in Mason County, Texas.

Figured specimen.—State Univ. Iowa, 4989.

GONIATITES CHOCTAWENSIS Shumard
Plate 62, figure 7; plate 63, figures 1–8; plate 64, figures 1–12.

Goniatites choctawensis SHUMARD, 1863, St. Louis Acad. Sci. Tr., vol. 2, pp. 109–110; SMITH, 1903, U. S. Geol. Surv. Mon. 42, pp. 67–68, 144; GIRTY, 1909, U. S. Geol. Surv. Bull. 377, pp. 9, 10, 54, 56, 58, 59–62, 63, 64, 102, pl. 13, figs. 1–11b; GIRTY, 1911, U. S. Geol. Surv. Bull. 439, pp. 12, 13, 18, 19, 20, 22, 25, 97–99, 100, pl. 15, figs. 1–7; GIRTY, 1915, U. S. Geol. Surv. Bull. 593, pp. 14, 129–130, pl. 5, figs. 4, 5; CRONEIS, 1930, Arkansas Geol. Surv. Bull. 3, pp. 55, 64, 71; GIRTY, 1934, Am. Assoc. Petroleum Geol., Bull., vol. 18, p. 1543; PLUMMER and SCOTT, 1937, Texas Univ. Bull. 3701, pp. 15, 29, 30, 106, 107, 113–114, 381, 383, 384, 399, pl. 7, figs. 3–6; SCHUCHERT, 1943, Stratigraphy of the eastern and central United States, pp. 852, 912.

Glyphioceras incisum [part?] HYATT, 1893, Texas Geol. Surv., Ann. Rept. 4, pp. 471–472, pl. 47, figs. 44–48; [part?] SMITH, 1897, Calif. Acad. Sci., Pr., 3rd ser., Geol., vol. 1, pp. 111–122, pls. 13–15; [part?] PLUMMER and MOORE, 1922, Texas Univ. Bull. 2132, pp. 29, 30.

Glyphioceras cumminsi HYATT, 1893, Texas, Geol. Surv., Ann. Rept. 4, pp. 467–471, pl. 47 figs. 33–43; [part?] PLUMMER and MOORE, 1922, Texas Univ. Bull. 2132, pp. 29, 30; CLOUD and BARNES, Texas Univ. Bull., no. 4621, (1948), p. 55.

Goniatites kentuckiensis MILLER, 1889, North American geology and paleontology for the use of amateurs, students, and scientists, pp. 439–440, text fig. 740; MILLER and GURLEY, 1896, Illinois State Mus. Nat. Hist. Bull. 11, pp. 40–41, pl. 5, fig. 1; SMITH, 1903, U. S. Geol. Surv. Mon. 42, pp. 14, 77, 81, 144, pl. 17, fig. 1; PLUMMER and SCOTT, 1937, Texas Univ. Bull, 3701, p. 114; MILLER and FURNISH, 1940, Jour. Paleontology, vol. 14, pp. 356, 357, 361–363, pl. 46, figs. 1–13; GORDON, 1944, Am. Assoc. Petroleum Geol., Bull., vol. 28, p. 1633; SHIMER and SHROCK, 1944, Index fossils of North America, p. 571, pl. 234, figs. 9, 10.

Goniatites striatus [part] SMITH, 1903, U. S. Geol. Surv. Mon. 42, pp. 14, 15, 62, 63, 66, 67, 68, 69, 70, 77, 79, 80–81, 87, 144, pl. 10, figs. 1–11; pl. 26, figs. 6–13.

Goniatites crenistria [part] SMITH, 1903, U. S. Geol. Surv. Mon. 42, pp. 14, 15, 63, 66, 67, 68–76, 79, 80, 81, 144, pl. 10, figs. 12–16; pl. 14, figs. 1–12; pl. 15, figs. 1–9; pl. 16, figs. 1a–1j; pl. 26, figs. 1–5; CRONEIS, 1930, Arkansas Geol. Surv., Bull. 3, pp. 55, 71; SHIMER and SHROCK, 1944, Index fossils of North America, p. 571, pl. 234, figs. 4, 5.

Goniatites sp. GIRTY, 1918, U. S. Geol. Surv. Prof. Paper 110, p. 39.

?Glyphioceras n. sp. PLUMMER and MOORE, 1922, Texas Univ. Bull. 2132, pp. 29, 44, pl. 7, fig. 12.

Glyphioceras (*Goniatites*) *choctawensis* PLUMMER and MOORE, 1922, Texas Univ. Bull. 2132, pp. 29, 30.

Goniatites subcircularis CRONEIS, 1930 Arkansas Geol. Surv. Bull. 3, pp. 56, 71.

Goniatites newsomi CRONEIS, 1930, Arkansas Geol. Surv. Bull. 3, pp. 56, 71.

Nuculoceras incisum [part] PLUMMER and SCOTT, 1937, Texas Univ. Bull. 3701, pp. 15, 29, 30, 33, 106–108, 109, 113, 383, 384, 399, pl. 7, fig. 10 [not 7–9, 11–14].

Goniatites choctawensis MILLER and YOUNGQUIST, 1948, Jour. Paleontology, vol. 22, pp. 658–660, pl. 95, figs. 16, 17; pl. 96, figs. 1–3, 9-12; pl. 97, figs. 1–21, pl. 98, figs. 1–13; pl. 99, figs. 1–19.

Among the more than 3000 ammonoids available now from the White Pine shale, the genus *Goniatites s. s.* is represented by slightly over 90 specimens. All of them are internal molds, only a few individuals retain portions of the test, and none of them retain the living chamber.

American specimens of *Goniatites* have recently been given detailed consideration by Miller and Youngquist (1948, pp. 658–660). After a study of a number of specimens from the "Meramec" of Kentucky, approximately contemporaneous beds in Arkansas, the Caney of Oklahoma, and the Barnett and Helms formations of Texas, they concluded that, although variations occur, it does not seem practical at present to delimit more than one species, and Shumard's name *G. choctawensis* was used to include all these specimens because of priority. However, the possibility of dividing *G. choctawensis* into four varieties was suggested. These varieties and their diagnostic characteristics were given as: (1) *G. choctawensis choctawensis*—best typified by some of the Caney specimens. Relatively narrow conch, rather long, narrow, subangular first lateral saddles in the suture, and crenulate shell ornamentation. (2) *G. choctawensis kentuckiensis*—represented by some of the specimens known from the "Meramec" of Rockcastle County, Kentucky. Stout, globular conch; test shows coarse longitudinal lirae. (3) *G. choctawensis cumminsi*—exemplified by some of the Barnett specimens of Texas. Conch narrow, with fine but distinct longitudinal lirae on the test. (4) *G. choctawensis barnettensis*—also represented by some Barnett specimens. They possess a relatively narrow conch; the test bears fine transverse lirae.

As has been pointed out, these varieties may not be particularly useful, for they are defined in part at least by the ornamentation of the test, a structure which the great majority of the specimens of *Goniatites* do not retain. Also, insofar as can be ascertained, the varieties have no stratigraphic value beyond that of the species and are, in part at least, morphologically gradational.

The representatives of *Goniatites choctawensis* from the White Pine shale seem to fall into two varieties. Some of the specimens have rather obese conchs, and, although they do not retain the test, resemble *G. choctawensis kentuckiensis* (*cf.* pl. 64, figs. 1–3—White Pine shale specimens, and figs. 11, 12—Kentucky specimens Note also similarity of sutures—text figure 3). Others in the collections resemble *G. choctawensis barnettensis* exhibiting a relatively narrow conch and transverse (but not longitudinal) lirae on the test (*e. g.*, pl. 63, fig. 5).

The largest representative of this genus secured from the White Pine shale is the form illustrated by figures 6–8 on plate 63. It is a completely septate internal mold which has been somewhat distorted during preservation. The maximum diameter attained is approximately 51 mm. Near the adoral end of the outer volution, the conch is about 31 mm. wide and 24 mm. high. Corresponding measurements near the adapical end of the same volution are about 23 mm. and 18 mm., respectively. The maximum diameter of the umbilicus is about 9 mm. The umbilical shoulders are abrupt and the umbilical walls are steep. Superficially, the conch appears to be of the narrow type of *G. choctawensis barnettensis*, and faint suggestions of transverse growth lines support this relationship. However, measurements of the conch indicate that it is distinctly wider than high, and its suture at a diameter of about 42 mm. (see text figure 3), is strikingly close to that of the more rotund variety of *Goniatites, G. choctawensis kentuckiensis.*

In summary, it can be stated that the representatives of *Goniatites* now available from the White Pine shale of Nevada indicate that, whereas variations occur, they are gradational and no more than a single species can be effectively delimited.

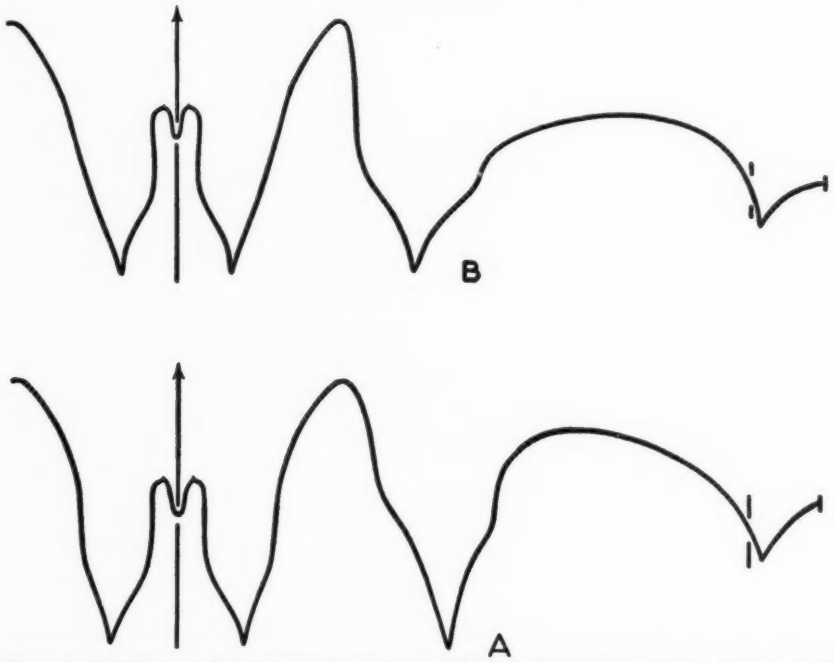


FIG. 3—Sutures of *Goniatites choctawensis kentuckiensis* Miller. A is based on the specimen represented by figures *6–8* on plate 63 at a diameter of 42 mm., from the White Pine shale of Nevada, ×2½. B (from Miller and Furnish) is based on a specimen from the Meramec series of Kentucky, ×2½.

Occurrence.—White Pine shale in at least two localities in east-central Nevada: (1) Pancake Range (locality 4), (pl. 63, figs. 1–3, 6–8; pl. 64, figs. 1–5); (2) Snake Range (locality 1), (pl. 63, figs. 4, 5). Probably occurs also in the same formation in the Schell Creek Range, (locality 2), but poor preservation of the specimens from that place makes identification of *G. choctawensis* uncertain. Conspecific specimens are known from the following: the Helms formation of west Texas; the Barnett of north-central

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EXPLANATION OF PLATE 62

All specimens illustrated on this plate except figure *7* are from the White Pine shale of east-central Nevada.

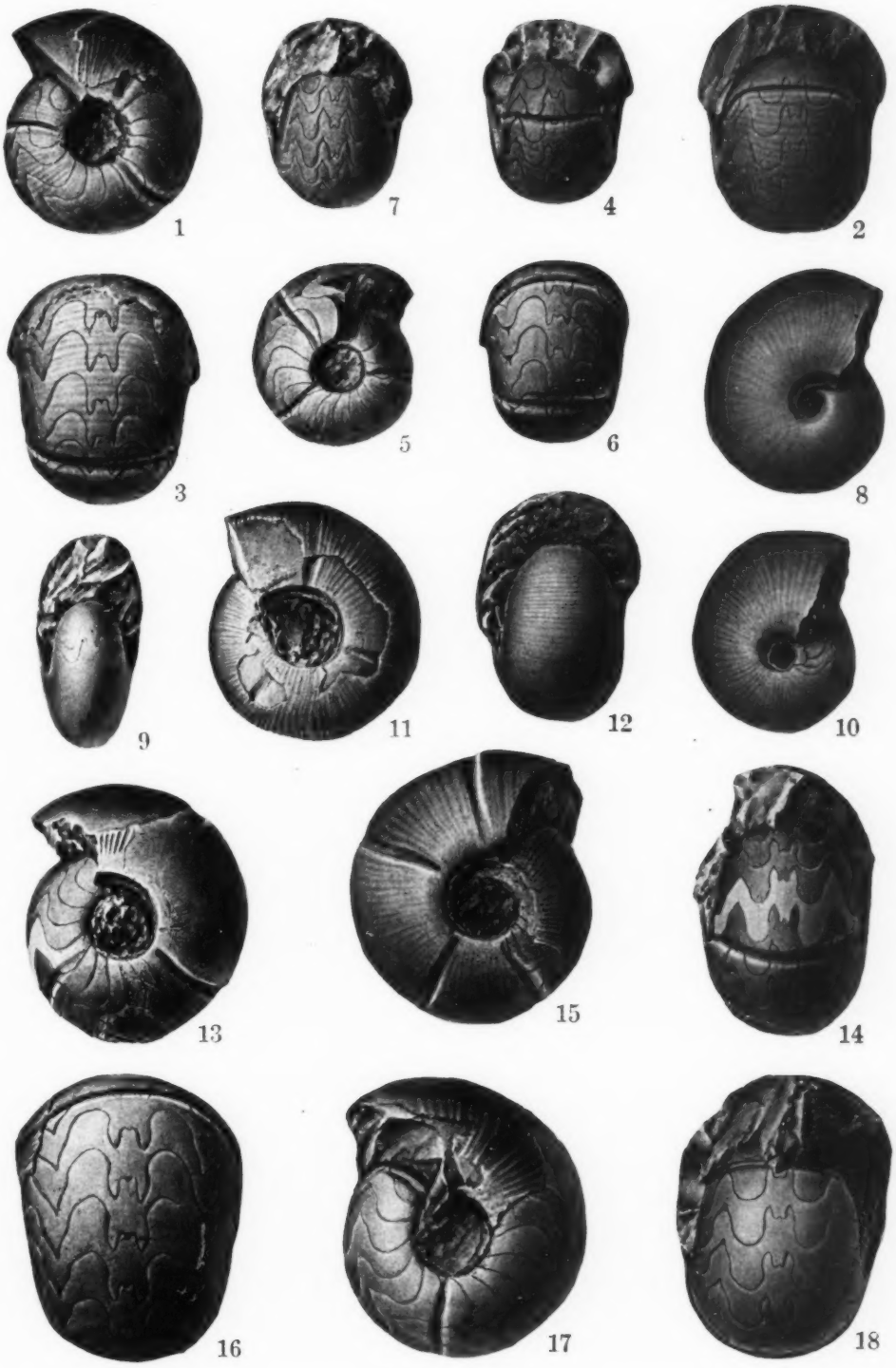
FIGS. *1–6—Cravenoceras hesperium* Miller and Furnish. Figures *1–3*, a small but exceptionally well-preserved individual from the central portion of the Schell Creek Range, White Pine County, ×2½; figures *4–5*, an internal mold from an eastern spur of the Pancake Range, Nye County, ×2. (p. 291)

7—Goniatites choctawensis Shumard. Apertural view of a small specimen from the Barnett shale about 8 miles southwest of Mason, Mason County, Texas, ×1½ (from Miller and Youngquist). (p. 296)

8–10—Anthracoceras? columbrellus Miller and Furnish. Figures *9*, *10*, represent one specimen. Both individuals (from Miller and Furnish) are from the southern portion of the Snake Range, White Pine County, ×2½. (p. 278)

11–15—Cravenoceras nevadense Miller and Furnish. Figures *11*, *12*, a typical specimen from the central portion of the Schell Creek Range, .7 mile west of Connor's Pass, White Pine County, ×1; figures *13*, *14*, a completely septate specimen from a locality in an eastern spur of the Pancake Range, Nye County, ×1½; figure *15*, an individual retaining part of the living chamber, from the same locality as the preceding, ×2. (p. 295)

16–18—Cravenoceras hesperium Miller and Furnish. Part of a small phragmacone, from the same horizon and locality as figures *13–15*, ×2½. (p. 291)



Youngquist, Nevada Mississippian Cephalopods

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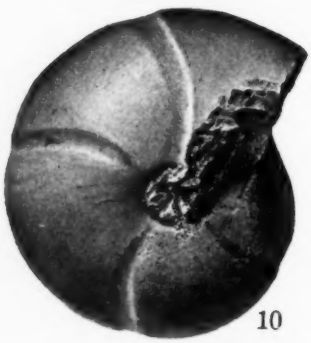
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Youngquist, Nevada Mississippian Cephalopods

Texas; the Caney shale of Oklahoma; the Moorefield, Ruddell, Batesville, and Fayetteville formations of Arkansas; and the "Meramec" of Kentucky. *G. choctawensis* is of widespread occurrence in the eastern hemisphere where it is generally regarded as characteristic of the middle and upper Viséan.

Figured specimens.—State Univ. Iowa, 4990 (pl. 63, figs. 1–3), 4991 (pl. 63, figs. 6–8), 4992 (pl. 64, figs. 1–3), 4993 (pl. 64, figs. 4, 5); U. S. National Museum (pl. 62, fig. 7; pl. 64, figs. 6, 8); State Univ. Iowa, 4994 (pl. 63, figs. 4, 5); and Princeton University (pl. 64, figs. 11, 12).

EUMORPHOCERAS BISULCATUM Girty
Plate 58, figures 4, 5

Eumorphoceras bisulcatum GIRTY, 1909, U. S. Geol. Surv. Bull. 377, pp. 10, 67–70, pl. 11, figs 15–19a; [part] WEDEKIND, 1918, Palaeontographica, Bd. 62, p. 139; ? GIRTY, U. S. Geol. Surv. Prof. Paper 110, p. 39; MORGAN, 1924 [Oklahoma] Bur. Geol. Bull. 2, p. 54; BISAT, 1924, The Naturalist, p. 87; [part?] ——, 1924, Yorkshire Geol. Soc., Pr., n. ser., vol. 20, pp. 72, 96–98, 99, 100, 117, pl. 6, figs. 1–5; pl. 10, fig. 12; [part?] SCHMIDT, 1925, Preus. Geol. Landesanstalt, Jahrb., Bd. 45, pp. 497, 500, 501, 507, 511, 512, 530, 575, 577, 578, 579, 582, 583, 584–585, pl. 22, fig. 5; pl. 25, figs., 2, 3; [part?] JACKSON, 1927, Manchester Geol. Assoc., Jour., vol. 1, pp. 17, 23, 24, 26, 27, 29–32; ? WADDINGTON, 1927, Manchester Geol. Assoc., Jour. vol. 1, pt. 1, p. 42; [part?] BRAY, 1927, Manchester Geol. Assoc., Jour., vol. 1, pp. 52, 53, 54–55; [part?] BISAT, 1928, C. R. Cong. l'avanc. études Stratigr. Carbon. Heerlen, 1927, pp. 127, 132, pl. 6; MAILLIEUX and DEMANET, 1929, Soc. Belge Géol., Bull., t. 38, p. 129, tab. 1; [part?] SCHMIDT, 1929, Tierische Leitfossilien des Karbon, Gürich's Leitfossilien, Lief. 6, pp. 70–71, pl. 19, figs. 5, 6; [part?] BISAT, 1930, Leeds Geol. Assoc., Tr., pt. 20, p. 31; DELÉPINE, 1930, Soc. géol. France, Livre Jubilaire (1830–1930), t. 1, p. 228; [part?] DORLODOT, 1930, Inst. géol. Univ. Louvain, Mém., t. 6, fasc. 1, pp. 7, 22, 48, 49, tab. B; [part?] DELÉPINE, 1930, Inst. géol. Univ. Louvain, Mém., t. 6, fasc. 1, pp. 57–58, 62, 63, pl. 1, figs. 1–5; [part?] JACKSON, 1930, Manchester Geol. Assoc., Jour., vol. 1, pt. 2, pp. 73, 75; ? MOORE, 1930, Manchester Geol. Assoc., Jour., vol. 1, pp. 106, 107, 108; ? CRONEIS, 1930, Arkansas Geol. Survey, Bull. 3, p. 56; ? BISAT, 1931, Leeds Geol. Assoc., Tr., vol. 5, pp. 27, 30; [part ?] DELÉPINE, 1931, C. R. Cong. Soc. Savantes, 1928, Lille, p. 135; [part] MAILLIEUX, 1933, Mus. roy. Hist. nat. Belg. Patrimoine, pp. 100, 102, pl. 10, fig. 139; [part?] BISAT, 1933, Geol. Assoc., Pr., vol. 44, pt. 3, p. 256, pl. 30; ? VERHOOGEN, 1934, Soc. Géol. Belg., Ann., t. 58, Bull. 2, p. B98, B99; [part?] SCHMIDT, 1934, Preuss, Geol. Landesanstalt, Jahrb., Bd. 54, pp. 442–451, 454, 455, 459–461; ? BISAT, 1934, Leeds Geol. Assoc., Tr., vol. 5, pt. 2, p. 115; ? HUDSON, 1934, Leeds Geol. Assoc., Tr., vol. 5, pt. 2, pp. 119–123; ? DELÉPINE, 1935, Soc. géol. France, Bull., 5e sér., t. 5, pp. 172, 184–185, pl. 8, figs. 5, 6; ? WOOD, 1936, Liverpool Geol. Soc., Pr., vol. 17, pt. 1, pp. 16, 17, 23; ? DEMANET, 1936, Mus. roy. Hist. nat. Belg., Bull., t. 12, no. 44, pp. 1, 2, 4–6, pl. 2, fig. 5; [part?] BISAT, 1936, Internat. Geol. Cong., Rept. 16th sess., vol. 1, pp. 531, 534, tab. 1; ? DELÉPINE, 1937, C. R. deuxième Cong. l'études Stratig. Carbon, Heerlen, 1935, pp. 145, 152, 153; [part] PLUMMER and SCOTT, 1937, Texas Univ. Bull. 3701, pp. 15, 16, 175–176, 378, 382–384, 399, 401, pl. 38, fig. 7 [not 4–6]; [part?] HUDSON and MITCHELL, 1937, Geol. Surv., Summ. Prog. for 1935, pt. 2, p. 5; [part?] HUDSON, 1938, Geol. Assoc. Pr., vol. 49, pt. 3, pp. 316, 321, 322; [part?] HUDSON, 1938, Geol. Assoc., Pr., vol. 49, pt. 4, p. 357; [part?] HUDSON and EDWARDS, 1938, Geol. Assoc., Pr., vol. 49, pt. 4, pp. 358, 362, 363, 371; [part?] SCHMIDT, 1938, Geol. niederrheinisch-westfälischen Steinkohlengebietes im auftrage westfäl. Bergewerkschaftskasse Bochum, p. 118; ——, [part] 1938, Geol. Jahresberichte, Bd. 1, p. 388; ? DEMANET, 1938, Mus. roy. Hist. nat. Belg., Mém., no. 84, pp. 115, 119, 177; ? ——, 1938, Mus. roy. Hist. nat. Belg., Patrimoine, pp. 175, 245, pl. 130, figs. 6–9, and stratigraphic chart; ? HUDSON, 1939, Yorkshire Geol. Soc.,

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EXPLANATION OF PLATE 63

All specimens illustrated on this plate are from the White Pine shale of east-central Nevada.

FIGS. *1–8*—*Goniatites choctawensis* Shumard. Figures *1–3*, three views of a completely septate specimen, from an eastern spur of the Pancake Range, about 5 miles north of Duckwater, Nye County, ×1½; figures *4, 5*, a specimen retaining small portions of the test, from the southern portion of the Snake Range, White Pine County, ×1½; figures *6–8*, a large, well-preserved internal mold, from the same horizon and locality as figures *1–3*, ×1. (p. 296)

9–12—*Cravenoceras merriami* Youngquist, n. sp. Syntypes. Figure *9*, lateral view of a specimen retaining much of the living chamber, from the central portion of the Schell Creek Range, .7 mile west of Connor's Pass, White Pine County, ×*1*; figures *10, 11*, lateral and apertural views of an individual from an eastern spur of the Pancake Range, about 5 miles north of Duckwater, Nye County, ×1; figure *12*, a large individual from the same horizon and locality as the preceding, ×1. (p. 291)

n. ser., vol. 23, pp. 327, 329, 330, 332, 336, 337, 339; [part?] DEMANET, 1941, Mus. roy. Hist. nat. Belg., Mém. 97, pp. 15, 27, 29, 30, 32, 35–42, 47–48, 49, 56–58, 137–140, 142, pl. 5, figs. 150–20; [part?] DELÉPINE, 1941, Protec. L'État français Maroc, Direct. gén. trav. publics, Div. Mines et Géol., Serv. géol., Notes et Mém., No. 56, pp. 12, 20, 26, 32, 34, 37, 39–41, 79; MOORE, 1941, Yorkshire Geol. Soc., Pr., n. ser., vol. 24, pp. 253, 257; [part?] HUDSON and COTTON, 1943, Yorkshire Geol. Soc., Pr., n. ser. vol. 25, pp. 142, 145, 160–164, 167, 171; [part] SCHUCHERT, 1943, Stratigraphy of the eastern and central United States, p. 912 [not 852]; [part?] HUDSON, 1944, Leeds Philos. Soc. Pr., Sci., sect., vol. 4, pt. 3, pp. 233–241; [part] SHIMER and SHROCK, 1944, Index fossils of North America, p. 571, pl. 233, figs. 16–18; [part?] DUNHAM and STUBBLEFIELD, 1945, Quart. Jour. Geol. Soc. London, vol. 100, pp. 209, 212, 235, 238, 240, 258–260, pl. 11, figs. 4a–4c; [part?] HUDSON and COTTON, 1945, Quart. Jour. Geol. Soc. London, vol. 101, pp. 1, 2, 4, 7–11, 13, 14; ? HUDSON, 1945, Quart. Jour. Geol. Soc. London, vol. 101, pp. 135–136; [part?] STUBBLEFIELD, 1945, Quart. Jour. Geol. Soc. London, vol. 101, pp. 136–137; ? HUDSON, 1945, Geol. Mag., vol. 82, no. 1, pp. 2–5; ? ——, 1945, Yorkshire Geol. Soc., Pr., n. ser., vol. 25, pt. 4, pp. 318, 320; ? MOORE, 1945, Yorkshire Geol. Soc., Pr., n. ser., vol. 25, p. 333; [part?] MOORE, 1946, Yorkshire Geol. Soc., Pr., n. ser., vol. 25, pp. 388, 393, 394, 417 430–433, 439, pl. 22, fig. 3; pl. 23, fig. 7; pl. 25, fig. 5; pl. 27, figs. 1, 2; ? JACKSON, 1946, Liverpool Geol. Soc., Pr., vol. 19, pt. 3, pp. 161–164; [part] CLOUD and BARNES, Texas Univ. Bull. 4621; MILLER and YOUNGQUIST, 1948, Jour. Paleontology, vol. 22, pp. 662–665, pl. 100, figs. 9–17.

Two specimens which seem to be clearly referable to *E. bisulcatum* were secured from the White Pine shale in the southern part of the Snake Range, east-central Nevada. One of these is rather small, being some 11 mm. in maximum diameter. It is an internal mold to which only small portions of the test adhere. No traces of the sutures are discernible on at least the outer volution of this specimen. The conch is subglobular in form, being rounded both laterally and ventrally and moderately impressed dorsally. Near the adoral end of the outer volution the conch is approximately 5 mm. high and 5 mm. wide. Corresponding measurements near the adapical end of the same volution are 3 mm. and 4 mm., respectively.

Laterally and dorso-laterally there are about 20 rounded sinuous ribs on each side of the outer volution of the conch. These curve orad in their ventral portions, extending to a longitudinal groove or sulcus which is located on the lateral zone of the conch about a millimeter from the venter. Traces of the growth lines which are retained adorally show the initial presence of a rather deep but rounded U-shaped ventral sinus, a narrowly rounded ventrolateral salient and a broadly rounded lateral sinus.

The umbilical shoulder is indistinct and the umbilical wall is rounded. The diameter of the umbilicus is about a third that of the maximum diameter of the specimen.

The larger of these specimens is also an internal mold on which no sutures are visible. It measures slightly more than 20 mm. in maximum diameter and is fragmentary. The adapical portion of the outer volution of the conch is approximately as wide as high, measuring 7 mm. At the adoral end of the same volution, the height of the conch is about 9½ mm. and the width about 9 mm. In the great majority of details this speci-

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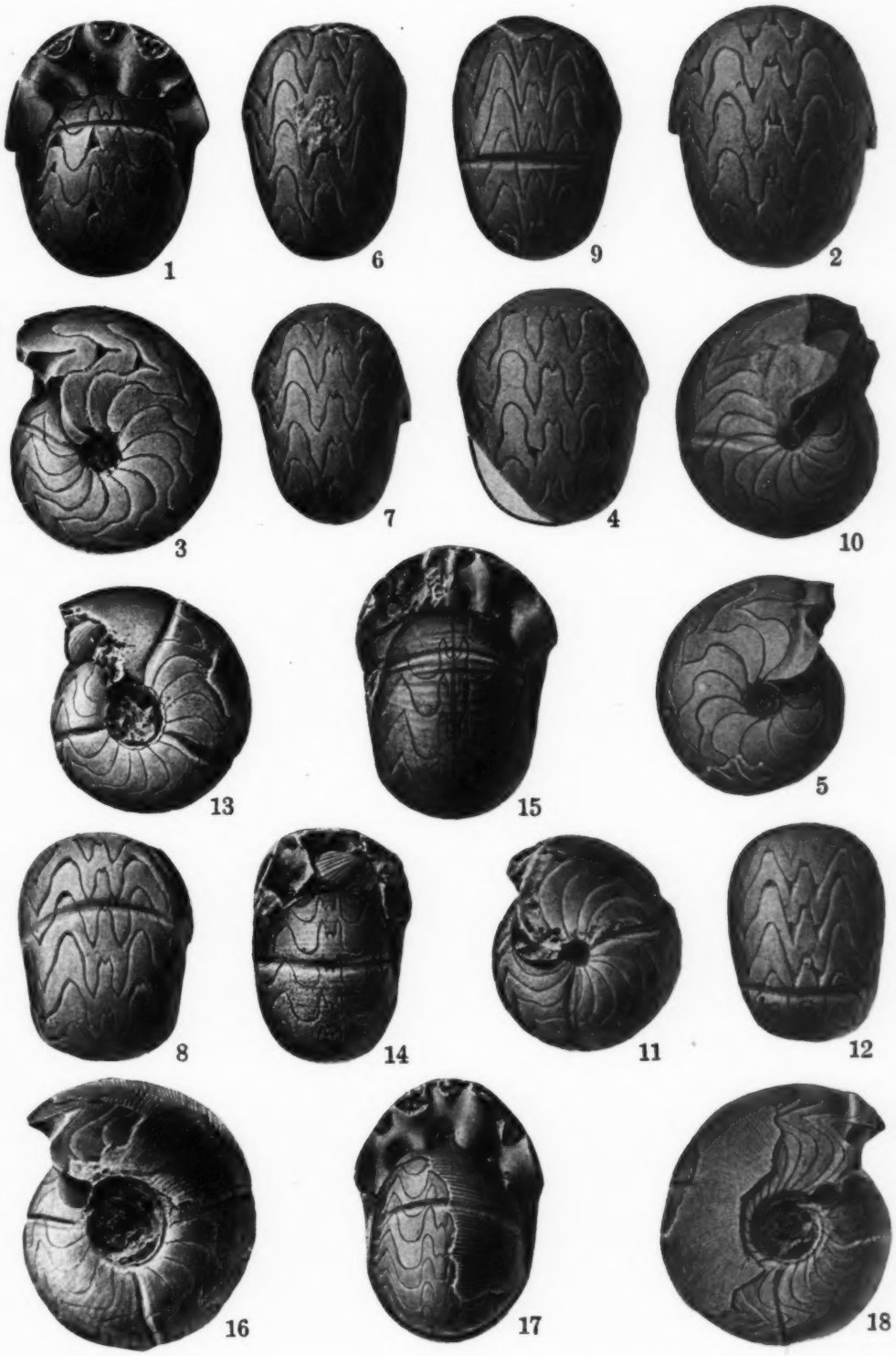
EXPLANATION OF PLATE 64

FIGS. *1–12*—*Goniatites choctawensis* Shumard. Figures *1–5*, two globose specimens from the White Pine shale at an outcrop in an eastern spur of the Pancake Range, 5 miles north of Duckwater, Nye County, Nevada, *1–3*, ×2; *4*, *5*, ×1½; figures *6–8*, three individuals from the Barnett formation, *6*—from a locality 8 miles southwest of Mason, Texas, ×1½; *7*—from about 2½ miles south-southeast of San Saba, Texas, ×1½; *8*—same locality as figure *7*, ×1½; figures *9*, *10*, a completely septate specimen from the Caney shale of Pontotoc County, Oklahoma, ×1½; *11*, *12*, an obese form from the "Meramec" of Rockcastle County, Kentucky, ×1. Figures *6–10*—from Miller and Youngquist; figures *11*, *12*—from Miller and Furnish. (p. 296)

13–16—*Cravenoceras nevadense* Miller and Furnish. Figures *13*, *14*, an average-sized specimen retaining only the extreme adapical portion of the living chamber, from the central portion of the Schell Creek Range, .7 mile west of Connor's Pass, White Pine County, ×2; figures *15*, *16*—a moderately large individual retaining part of the test, ×1½. (p. 295)

17, *18*—*Cravenoceras richardsonianum* (Girty). Apertural and lateral views of a well-preserved specimen from the Caney shale, Pontotoc County, Oklahoma, ×1. (p. 293)



Youngquist, Nevada Mississippian Cephalopods

men is in close agreement with the somewhat smaller specimen just described. One slight difference is apparent in the more nearly mature portion of this specimen—the longitudinal groove or sulcus on the ventrolateral zone of the conch is rather prominent and it is bordered ventrally by a small ridge. This ridge is not very distinct adapically.

Occurrence.—Both of these specimens were secured from the White Pine shale in the Snake Range (locality 1). The species has tentatively been reported from the same formation in the Inyo Mountains of southeastern California. The syntypes of *E. bisulcatum* came from the Caney shale of Oklahoma, and other American representatives have been described from the Barnett shale of Texas. Conspecific specimens are reported to occur widely, and have been recorded from England, Scotland, Belguim, Holland, Germany, and the French Pyrenees. A questionable representative is known from Morocco.

Figured Specimens.—State Univ. Iowa, 4995 (fig. 4), and 4996 (fig. 5).

EUMORPHOCERAS PLUMMERI Miller and Youngquist
Plate 58, figures 1–3

Eumorphoceras bisulcatum [part?] BISAT, 1924, Yorkshire Geol. Soc., Pr., n. ser., vol. 20, pp. 72, 96–98, 99, 100, 117, pl. 6, figs. 1–5; pl. 10, fig. 12; [part?] SCHMIDT, 1925, Preuss. Geol. Landesanstalt, Jahrb., Bd. 45, pp. 497, 500, 501, 507, 511, 512, 530, 575, 577, 578, 579, 582–585, pl. 22, fig. 5; pl. 25, figs. 2, 3; [part?] BRAY, Manchester Geol. Assoc., Jour., vol. 1, pt. 1, p. 54; [part?] BISAT, 1928, C. R. Cong. l'avanc. études Stratigr. Carbon, Heerlen, 1927, pp. 127, 132, pl. 6; ? MAILLIEUX and DEMANET, 1929, Soc. Belge. Géol., Bull., t. 38, p. 129, tab. 1; [part?] SCHMIDT, 1929, Tierische Leitfossilien des Karbon, Gürich's Leitfossilien, Lief, 6. pp. 70–71, pl. 19, figs. 5, 6; [part?] BISAT, 1930, Leeds Geol. Assoc. Tr., pt. 20, p. 31; [part?] DELÉPINE, 1930, Inst. géol. Univ. Louvain, Mém., t. 6, fasc. 1, pp. 57–58, 62, 63, pl. 1, figs. 1–5; ? MOORE, 1930, Manchester Geol. Assoc., Jour., vol. 1, pp. 106–108; ? BISAT, 1931, Leeds Geol. Assoc., Tr., vol. 5, pp. 27, 30; [part?] DELÉPINE, 1931, C. R. Cong. Soc. Savantes, 1928, Lille, p. 135; [part?] MAILLIEUX, 1933, Mus. roy. Hist. nat. Belg., Patrimoine, pp. 101, 102, pl. 10, fig. 139; [part?] BISAT, 1933, Geol. Assoc., Pr., vol. 44, pt. 3, p. 256, pl. 30; VERHOOGEN, 1934, Soc. Géol., Belg., Ann., t. 58, Bull. 2, p. B98, B99; [part?] SCHMIDT, 1934, Preuss. Geol. Landesanstalt, Jahrb., Bd. 54, pp. 442–451, 454, 455, 459–461; ? BISAT, 1934, Leeds Geol. Assoc., Tr., vol. 5, pt. 2, pp. 115–117; ? HUDSON, 1934, Leeds Geol. Assoc., Tr., vol. 5, pt. 2, pp. 119–123; ? WOOD, 1936, Liverpool Geol. Soc., Pr., vol. 17, pt. 1, pp. 16, 17, 23; [part?] BISAT, 1936, Internat. Geol. Cong., Rept. 16th sess., vol. 1, pp. 531, 534, tab. 1; [part] PLUMMER and SCOTT, 1937, Texas Univ. Bull. 3701, pp. 15, 16, 175, 176, 378, 382–384, 399, 401, pl. 38; figs. 4–6 [not 7]; [part?] HUDSON and MITCHELL, 1937, Geol. Surv., Summ. Prog. for 1935, pt. 2, p. 5; [part?] HUDSON, 1938, Geol. Assoc., Pr., vol. 49, pt. 3, pp. 316, 321–322; [part?] HUDSON, 1938, Geol. Assoc., Pr., vol. 49, pt. 4, p. 357; [part?] HUDSON and EDWARDS, 1938, Geol. Assoc., Pr., vol. 49, pt. 4, pp. 358, 362, 363, 371; [part?] SCHMIDT, 1938, Geol. niederrheinisch-westfälischen Steinkohlengebietes im auftrage westfäl Berggewerkschaftskasse Bochum, p. 118; [part] ——, 1938, Geol. Jahresberichte, Bd. 1, p. 388; ? DEMANET, 1938, Mus. roy. Hist. nat. Belg., Mém., No. 84, pp. 115, 119, 177; ? ——, 1938, Mus. roy. Hist. nat. Belg., Patrimoine, pp. 175, 245, pl. 130, figs. 6–9, and stratigraphic chart; ? HUDSON, 1939 Yorkshire Geol. Soc., n. ser., vol. 23, pp. 327, 329, 330, 332, 336, 337, 339; [part?] DEMANET, 1941, Mus. roy. Hist. nat. Belg., Mém. 97, pp. 15, 27, 29, 30, 32, 35–42, 47–48, 49, 56–58, 137–140, 142, pl. 5, figs. 15–20; [part?] DELÉPINE, 1941, Protec. l'État français Maroc, Direct. gén. Trav. publics, Div. Mines et Géol., Serv. géol., Notes et Mém., No. 56, pp. 12, 20, 26, 32, 34, 37, 39–41, 79; [part?] HUDSON and COTTON, 1943, Yorkshire Geol. Soc., Pr., n. ser., vol. 25, pp. 142, 145, 160–164, 167, 171; [part] SCHUCHERT, 1943, Stratigraphy of the eastern and central United States, p. 912 [not 852]; [part?] HUDSON, 1944, Leeds Philos. Soc., Pr., Sci. sect., vol. 4, pt. 3, pp. 233–241; [part] SHIMER and SHROCK, 1944, Index fossils of North America, p. 571, pl. 233, figs. 16–18; [part?] DUNHAM and STUBBLEFIELD, 1945, Quart. Jour. Geol. Soc. London, vol. 100, pp. 209, 212, 235, 238, 240, 258–260, pl. 11, figs. 4a–4c; [part?] HUDSON and COTTON, 1945, Quart. Jour. Geol. Soc. London, vol. 101, pp. 1, 2, 4, 7–11, 13, 14; ? HUDSON, 1945, Quart. Jour. Geol. Soc. London, vol. 101, pp. 135–136; [part?] STUBBLEFIELD, 1945, Quart. Jour. Geol. Soc. London, vol. 101, pp. 136–137; ? HUDSON, 1945, Geol. Mag., vol. 82, no. 1, pp. 2–5; ? ——, 1945, Yorkshire Geol. Soc., Pr., n. ser., vol. 25, pt. 4, pp. 318, 320; [part?] MOORE, 1946, Yorkshire Geol. Soc., Pr., n. ser., vol. 25, pp. 388, 393, 394, 417, 430–433, 439, pl. 22, fig. 23; pl. 23, fig. 7; pl. 25, fig. 5; pl. 27, figs. 1, 2; ? JACKSON, 1946, Liverpool Geol. Soc., Pr., vol. 19, pt. 3, pp. 161, 162, 163, 164; [part] CLOUD and BARNES, Texas Univ. Bull. 4621; MILLER and YOUNGQUIST, 1948, Jour. Paleontology, vol. 22, pp. 665–667, pl. 100, figs. 1–4, 20, 21.

A single representative of this species was secured from the White Pine shale. Fortu-

nately, it is an exceptionally well preserved individual which is in part testiferous. The entire outer whorl is non-septate and presumably, therefore, the living chamber is something more than a volution in length.

Maximum diameter of the specimen is slightly less than 14 mm. The more nearly mature portion of the conch is laterally compressed and near the adoral end of the outer volution it is about 6 mm. high and 5 mm. wide. Adapically, however, the conch is not compressed laterally and is wider than high, the corresponding measurements at the adapical end of the outer volution are about 3 mm. and 3½ mm., respectively. Diameter of the umbilicus is about 3 mm.—slightly more than a fifth the diameter of the specimen. The umbilical shoulders are abrupt and marked by a small longitudinal ridge in which the sinuous ribs appear to terminate. The umbilical walls are essentially normal to the flattened lateral zones of the conch.

The test bears prominent sinuous ribs (some 20 on the outer volution) which diffuse ventrolaterally into traces of the growth lines. These growth lines form a small dorsolateral salient, a rounded lateral sinus, a narrowly rounded ventrolateral salient and a deep narrowly rounded ventral sinus. In the portions of the conch where both growth lines and ribs are present they closely parallel one another. On each lateral zone of the conch, somewhat less than a millimeter from the venter, there is a longitudinal groove or sulcus which appears to become increasingly prominent orad.

The Nevada specimen under consideration has been compared directly with the holotype of this species and the two individuals are very similar in every available particular. The sutures of the White Pine specimen are not visible but almost certainly they would agree with the suture of *E. plummeri* illustrated by Miller and Youngquist (1948, p. 664). It should perhaps be mentioned that the measurements of the adapical portion of the conch of this Nevada representative of *E. plummeri* can be compared to advantage with corresponding measurements of the fairly large specimen of *E. bisulcatum* also of the White Pine shale. That is, at a diameter of 14 mm. in the specimen of *E. plummeri*, the conch is 6 mm. high and 5 mm. wide, whereas in the representative of *E. bisulcatum* which is slightly more than 20 mm. in diameter the conch in the adoral portion is 9½ mm. high and 9 mm. wide. These measurements serve to emphasize the relatively narrower and more laterally compressed conch characteristic of *E. plummeri*.

Occurrence.—White Pine shale, Pancake Range (locality 4). The types of this species came from the Barnett formation at three localities in central Texas.

Figured specimen.—State Univ. Iowa, 4997.

GIRTYOCERAS MESLERIANUM (Girty)
Plate 58, figure 18

Adelphoceras meslerianum GIRTY, 1909, U. S. Geol. Surv. Bull. 377, pp. 10, 66–67, pl. 12, figs. 1–2a [not 3–3c]; WEDEKIND, 1914, Mitt. Mus. Stadt Essen, Heft 1, p. 11; MORGAN, 1924, [Oklahoma] Bur. Geol. Bull. 2, p. 54; BISAT, 1924, The Naturalist, p. 87; ? CRONEIS, 1930, Arkansas Geol. Surv. Bull. 3, pp. 56, 65; PLUMMER and SCOTT, 1937, Texas Univ. Bull. 3701, p. 174, pl. 38, figs. 17, 18; SCHUCHERT, 1943, Stratigraphy of the eastern and central United States, p. 852.

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Beyrichoceras meslerianum BISAT, 1924, Yorkshire Geol. Soc., Pr., n. ser., vol. 20, pp. 72, 82.

Dryochoceras brainerdi [and "*grainerdi*"] MORGAN, 1924, [Oklahoma] Bur. Geol. Bull. 2, pp. 185–186, pl. 52, figs. 7–7b.

Homoceras meslerianum [part?] SCHMIDT, 1923, Centralblatt f. Min., etc., Jahrg. 1923, No. 24, p. 745: [part?] ——, 1925, Preuss. Geol. Landesanstalt, Jahrb., Bd. 45, pp. 496, 499, 500, 508, 511, 530, 574, 576, 580, 581, pl. 21, fig. 18; pl. 24, figs. 24–26.

Histrioceras meslerianum [part?] SCHMIDT, 1923, Centralblatt f. Min., etc., Jahrg. 1923, No. 24, p. 745.

Sagittoceras meslerianum BISAT, 1928, C. R. Cong.

l'avanc. études Stratigr. Carbon, Heerlen, 1927, p. 125; [part?] SCHMIDT, 1929, Tierische Leitfossilien des Karbon, Gürich's Leitfossilien, Lief. 6, p. 69, pl. 18, figs. 20–22; ? BISAT, 1930, Leeds Geol. Assoc., Tr., pt. 20, p. 31; KOBOLD, 1933, Preuss. Geol. Landesanstalt, Jahrb., Bd. 53, pp. 477, 482, 505–506; BISAT, 1933, Geol. Assoc., Pr., vol. 44, p. 256; ——, 1936, Internat. Geol. Cong. Rept. 16th sess., vol. 1, pp. 531, 533; [part?] MOORE, 1936, Manchester Geol. Assoc., Jour., vol. 1, pp. 177, 178, fig. 2; [part?] HUDSON and MITCHELL, 1937, Geol. Surv., Summ. Prog. for 1935, pp. 25, 26; HUDSON, 1938, Geol. Assoc. Pr., vol. 49, pt. 3, p. 315; ? —— and COTTON, 1943, Yorkshire Geol. Soc., Pr., n. ser., vol. 25, p. 170.

Sagittoceras brainerdi MILLER, 1934, Am. Jour. Sci., 5th ser., vol. 28, pp. 31, 32; MOORE, 1936, Manchester Geol. Assoc., Jour., vol. 1, p. 177.

Goniolobоceras sp. CLOUD and BARNES, Texas Univ. Bull. 4621 (1948), p. 55.

Although the collections under consideration include several thousand goniatites, the genus *Girtyoceras* is represented by only a single specimen and it is fragmentary. A part of the phragmacone is preserved.

The maximum diameter of the preserved portion of the conch is 53 mm. At the adoral end of the specimen the maximum height and width of conch are about 33 mm. and 18 mm., respectively. Corresponding measurements some one-third of a volution apicad of this place are 23 mm. and 14 mm. indicating a relative heightening of the conch progressively orad. The conch is sublenticular in cross section and is decidedly angular ventrally. The umbilicus is small but deep.

Small portions of the test which adhere to the phragmacone show that the shell is thin. Fine growth lines preserved on portions of the ventrolateral zones of the conch indicate the initial presence of a narrow ventral sinus. Some one-third of the distance from the venter to the umbilicus, on each lateral zone of the conch there is a longitudinal sulcus or groove which is about 2 mm. wide and which is visible on both the test and the internal mold.

The specimen illustrated and described from the Barnett shale of Texas and referred to this species by Miller and Youngquist (1948) has been available for direct comparison with the Nevada form under consideration. In general physiognomy, and in the details of the sutures and growth lines, these specimens are strikingly similar, and there can be little doubt but that they are conspecific.

Occurrence.—White Pine shale, Pancake Range (locality 4). The types of this species came from the Caney shale of Oklahoma. Conspecific specimens are known from the Barnett formation of Texas and the Floyd shale of Georgia. *G. meslerianum* is of widespread occurrence in the upper Viséan of England and Europe.

Figured specimen.—State Univ. Iowa, 4998.

EPICANITES? sp.
Plate 58, figure 6

A single specimen which can not be generically determined with certainty was collected from the White Pine shale in the central portion of the Schell Creek Range. It is nautiliconic and is about 12 mm. in diameter. Four full volutions and a part of a fifth are preserved. The early portions of the conch are essentially circular in cross section; the more nearly mature portions tend to become somewhat compressed laterally and consequently slightly higher than wide. No trace of the test appears to have been preserved.

Superficially at least, this specimen resembles *Epicanites loeblichi* Miller and Furnish from the Caney shale of Oklahoma. On the basis of the associated fauna, the presence of *Epicanites* in the White Pine shale is not incompatible. However, attention should be called to an indication of what may be a trace of a suture on the outer volution of the White Pine specimen. If this structure is a suture it forms a single rounded U-shaped lateral saddle, and the specimen cannot be referred to *Epicanites*, although no other closely similar genus is known.

Occurrence.—The White Pine shale, Schell Creek Range (locality 2).

Figured specimen.—State Univ. Iowa, 4999.

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MUSCLE MARKS, HINGE AND OVERLAP FEATURES, AND CLASSIFICATION OF SOME LEPERDITIIDAE

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ABSTRACT—Interest in a new leperditiid from deep subsurface beds in Georgia has led to reinvestigation of muscle marks, and hinge and overlap structures of various Leperditiidae. In combination, these features are of special importance for the generic arrangement of the group.

The Leperditiidae appear to fall naturally into the two new subfamilies, Leperditiinae and Isochilininae. Three new genera, *Eoleperditia*, *Chevroleperditia*, and *Teichochilina*, are proposed, and *Leperditia*, *Herrmannina*, *Isochilina*, and *Dihogmochilina* are modified. New species include *Leperditia altiscalaris*, *Chevroleperditia chevronalis*, *Dihogmochilina straitcreekensis* and *Isochilina venosculptilis*. *Leperditia longigibbera* and *Herrmannina welleri* are proposed as new names. New descriptions, with new data and new illustrations, are given for *Leperditia scalaris*, *Herrmannina willsensis*, *Eoleperditia fabulites*, and *Isochilina ottawa*.

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INTRODUCTION

The desire to obtain more information bearing on the stratigraphic significance of a leperditiid ostracode, discovered in dark shale lying beneath Cretaceous deposits in an exploratory well in the coastal plain of Georgia (Swartz, 1945), has led to review of hinge and muscle-scar structures of a number of the American species commonly referred to *Leperditia* Rouault (1851), and to recognition of several features of morphologic interest.

SUBOCULAR CHEVRON-MARKS IN LEPERDITIIDAE

The species from the Georgia well is being given the specific name *chevronalis*, because the inner surface of each valve is marked, below the eye-pit, by a V-shaped ridge that on inner molds leaves a downwardly convex, chevron-like groove. Similar grooves occur on internal molds prepared from specimens of *Leperditia scalaris* Jones (1858) from the Late Silurian Decker limestone of New Jersey and Keyser limestone of Pennsylvania; *Leperditia altiscalaris* Swartz, n. sp., from the Late Silurian Rondout limestone of New Jersey; and *Herrmannina willsensis* (Ulrich and Bassler, 1923) from the Late Silurian Wills Creek formation of Virginia. Examples of all three of these species are figured and described in the present paper.

In valves that are satisfactorily preserved, the subocular ridge of the inner surface can be observed externally through the shell wall as markings whose fine details closely resemble those of the nearby, oval adductor scar. The markings are as a rule more clearly visible if the specimen is given a coating of water, a light oil, or other suitable substance. In some instances, clarity is improved where weathering has removed the outer layer of the shell; but many fresh valves are trans-

lucent enough to reveal the scars if the surface is properly treated. In most of the studied examples, the markings are confined to inner shell layers; but in *Dihogmochilina straitcreekensis* Swartz the V-mark produces a sharp, external groove.

In addition to the adductor scar and the subocular, chevron-like structure, there are other marks that likewise appear to represent points of muscle attachment. Some of these occur in the area between the limbs of the V-mark; other numerous, more minute spots may form as many as 9 or 10 small groups in the area dorsal to the eye tubercle. These accessory scars have been observed through the treated valve-exteriors in numerous examples, but in no case have reflections of them been recognized on internal molds. Accompanying camera lucida sketches show their approximate detail in valves of *Leperditia scalaris* Jones, *Herrmannina welleri* Swartz, n. name, and *Eoleperditia fabulites* (Conrad).

It is of much interest that markings of all these types have been illustrated by previous workers, though little taxonomic value has been accorded to them. Thus the chevron-like subocular marking is clearly indicated in Oehlert's (1877) figures of the genotype of *Leperditia, L. britannica* Rouault of the Devonian of France (see Plate 65, figures 1, 2), and likewise in Jones' (1858) drawings of *Leperditia scalaris*. It is finely delineated, along with the adductor scar and diagrammatized marks dorsal to the eye tubercle, in a sketch given by Kolmodin (1879) for *Herrmannina phaseolus* (Hisinger) of the Silurian of Gotland. (See Plate 65, figure 16.) The chevron-mark is shown by Jones (1891) in figures of his *Leperditia balthica* var. *guelphica* of the Middle Silurian of Durham, Canada, and is termed the escutcheon in the accompanying description. It is labelled the "augenfleck" by Kegel (1932), in his generalized diagram of the features of the leperditiid valve, and small marks dorsal to the eye tubercle are termed "periphere muskeleindrücke." The chevron-mark, but not the accessory scars, is roughly sketched in Kegel's illustrations of *Hermannina waldschmidti, H. strigosa, H. consobrina, H. lotzi, Briartina hassica, B. obtusa*, and *B. librata*, all from the Middle Devonian of Germany. As figured, the form of the V-mark, and the position of the termini in relation to the eye tubercle, are subject to considerable differences in the various species, and these details may in the future prove to have some value in specific differentiations, if they are illustrated with sufficient objectivity.

The full anatomical significance of the chevron-mark and of the smaller, more dorsal spots is not subject to direct proof. Nevertheless, the similarity of their detail to that of the adductor scar is so evident that they must certainly represent points of attachment of other muscles or at least of connective tissues. It is possible that the chevron-mark served to affix muscles connected with the mouth parts, since such muscles are anchored to the shell wall in some Recent Ostracoda (Zalanyi, 1929). The position of the small spots in the area dorsal to the eye tubercles suggests that some of the attached tissues may have supported organs such as the foregut; but possible connections with appendages cannot be effectively denied, and some of these scars may even have served to anchor muscles used for retraction of the abdomen.

From the facts that have been enumerated it is of course obvious that the subocular chevron-mark occurs widely in Silurian and Devonian species of *Leperditia*, in the broad sense in which that term has commonly been used, as well as in *Dihogmochilina* as it is somewhat questionably represented by *straitcreekensis*. Such marks will probably be found with further studies in many of the known leperditiids in which they have not hitherto been recognized. Consequently, much interest attaches to the clear evidence, here presented, that the chevron- or V-mark is absent both as an internal ridge and—save for a few tiny spots—as scars visible from the valve-exterior, in the Ordovician *Cytherina fabulites* Conrad (1843) which has long been regarded as a characteristic member of *Leperditia*; at least, the chevron-scar is absent in *fabulites* as represented by specimens loaned by the United States National Muesum through the courtesy of Dr. R. S. Bassler, and obtained from the Lowville limestone of St. Joseph Island, Canada; the Lebanon limestone of Tennessee; and the Glade limestone of Kentucky. The structure is likewise wanting in *fabulites-*

like material collected from the Middle Ordovician Nealmont limestone near State College, Pennsylvania, though the adductor scar and the dorsal spots are clearly visible.

Absence of the chevron-mark provides ample reason for removing *fabulites* from *Leperditia* and *Herrmannina;* and the species is here made the type of a new genus, named *Eoleperditia* to emphasize its early appearance and its apparent relationship to the general leperditiid stock.

HINGE FEATURES IN LEPERDITIIDAE

Though first emphasis has been placed on absence of the chevron-mark, there are other shell features in *Eoleperditia* that deserve recognition. In the first place, there are a number of valves in the National Museum collections of *fabulites* that have well-preserved hinge margins. The contact surface of the hinge of the right valve is flat and fairly broad, and has an obscure longitudinal groove. The hinge structure thus contrasts sharply with that of other leperditiids in which the hinge margin has been observed and described, since in the latter forms the hinge is finely and evenly denticulate throughout its length.

A taxodont-like hinge of this nature was discovered by Paeckelmann (1922) in *waldschmidti* of the Middle Devonian of Germany, and *waldschmidti* was proposed on this basis as the type of the genus *Herrmannella*. Kegel (1933) subsequently recognized that denticulate hinges had been figured in several species that earlier had been assigned to *Leperditia*, and pointed out that the character is of questionable value for erection of *Herrmannella*, since the nature of the hinge is not yet known in the *Leperditia* genotype, *britannica*. He concluded that *Herrmannella* had best be treated as a subgenus of *Leperditia*, differing from *Leperditia* sensu stricto in lack of the strong post-dorsal swelling that occurs in the left valve of *britannica*, and having a denticulate hinge that might or might not prove with further work to have generic significance. Kegel (1934) subsequently found that the name, *Herrmannella*, is preoccupied by *Hermannella* Canu of the Copepoda, and hence proposed *Herrmannina* for the leperditiid group.

The taxodont-like type of hinge is finely exemplified by molds of *Herrmannina willsensis* (Ulrich and Bassler), here illustrated from Late Silurian beds in Virginia (Plate 66, figures 11, 12). Hinge denticulation is likewise shown, though in a fashion less readily photographed, in preparations made from examples of *Leperditia scalaris* found in the Late Silurian Keyser limestone in Pennsylvania and Decker limestone in New Jersey. In *scalaris*, the left valve bears a distinct post-dorsal swelling like that of *britannica;* hence though the hinge detail is not yet known in *britannica* itself, hinge denticulation does occur in a species closely comparable to *britannica* in presence of the post-dorsal swelling, presence of chevron-mark, and character of valve overlap. It thus appears plausible that *Leperditia* proper will prove to have the hinge denticulate, and that separation of *Herrmannina* Kegel will have to rest solely on lack of the post-dorsal swelling of the left valve. On this basis, *Leperditia* and *Herrmannina* have been treated as distinct genera in the present paper; but *Herrmannina* could well be retained in *Leperditia* as a subgenus as was done by Kegel.

The new genus, *Eoleperditia*, differs from both *Leperditia* and *Herrmannina* in absence of hinge denticulation as well as of the chevron-mark, and this structural difference further bulwarks its treatment as a distinct genus.

The species of the Georgia well does not fall into any of the three foregoing generic groups. It has the subocular chevron-mark of *Leperditia* and *Herrmannina*, but has a non-denticulate hinge as in *Eoleperditia;* like *Herrmannina* and *Eoleperditia* it lacks the post-dorsal swelling found in the left valve of *Leperditia*. It is accordingly made the genotype of a fourth genus, *Chevroleperditia*.

Inner, Submarginal Prongs in *Eoleperditia*

A further feature of *Eoleperditia fabulites* that is associated with valve overlap will likely prove to have generic value. In the larger, right valve there are peculiar prongs that lie near the ventro-terminal margins and that, as was observed by Ulrich (1894), must have served as stops for the edge of the left valve. (See Plate 66, figures 7, 8.) The prongs are reflected externally by shallow pits. Similar prongs and pits occur in

the *fabulites*-like material from the Middle Ordovician Nealmont limestone of Pennsylvania; in *Leperditia catheyensis* Kirk (1928) of the Ordovician Catheys formation of Tennessee; and in *Leperditia groenlandica* Teichert (1937a) of the Ordovician of northern Greenland. These forms should all prove to be proper members of *Eoleperditia*, though investigation is needed of the details of the hinge and of the muscle scars.

No prongs of eoleperditiid type occur in *Leperditia scalaris*, *Herrmannina willsensis*, or *Chevroleperditia chevronalis;* nor have they been illustrated in any Silurian or Devonian species so far as the writer can discover. In *scalaris*, the left valve has a well-defined shoulder that acted as a stop for the edge of the overlapping right valve. (See Plate 65, figure 5.)

Musculature and Valve-Relations in *Isochilina* and *Dihogmochilina*

The members of *Eoleperditia*, *Chevroleperditia*, *Leperditia*, and *Herrmannina* all have the valves decidedly unequal, with strong ventral overlap of the right valve on the left. In contrast, the Late Silurian *Dihogmochilina straitcreekensis* has nearly equal valves with flattened submarginal borders like those of *Isochilina;* yet it possesses a subocular chevron-ridge closely similar to those found in *Chevroleperditia*, *Leperditia*, and *Herrmannina*, though not in *Eoleperditia*. This duplicate relationship in structure raises problems as to the derivation of *straitcreekensis*, and has led to inquiry into the nature of *Isochilina* and its genotype, *I. ottawa* Jones.

Isochilina ottawa was described by Jones in 1858 (1858, 1858a) from the "Calciferous sandrock" or Beekmantown at Grenville, southern Quebec, and from the Chazy limestone at nearby L'Orignal, Ontario. The species has not been carefully reinvestigated at any subsequent time, so far as the writer knows, though various brief comments have been published.

Some new data on the characters of *Isochilina ottawa* and thus of *Isochilina* have been furnished by collections kindly donated for the present study by G. Winston Sinclair and by Cecil Kindle. The collections sent by Sinclair were obtained from the Pamelia limestone one mile north of Aylmer, Quebec, and from beds at L'Orignal, Ontario, that according to Sinclair were classed as Chazy by Raymond in 1903, as Beekmantown by the same author in 1913. The slabs supplied by Kindle come from a quarter mile south of the Ottawa River, some 10 miles west of Ottawa; they are probably Chazyan, but were picked up during incidental collecting so that their horizon and locality were not carefully ascertained.

All of these slabs are closely similar in nature of matrix as well as in the characters of the abundant isochilinids. The writer does not feel sure that the material from L'Orignal really represents an appreciably older horizon than does that obtained from Aylmer or that from west of Ottawa. Specimens from each of the three collections are figured on an accompanying plate. There are some variations in outline of the shell and in strength of the post-ocular furrow, but these do not appear to justify specific differentiation. One specimen from near Aylmer differs markedly from all of the other observed shells in the presence of strong, externally raised venose lines, and hence is made the type of a new species.

The specimens identified with *I. ottawa* exhibit two features of much interest. In the first place, there are small pits on the flat border as was recognized in several *Isochilina* species by Jones; but these prove to be restricted to right valves, where they are reflections of tiny nodes or prongs on the under surface of the border. The edge of the left valve very likely fitted, when the shell was closed, between these nodes and the actual edge of the right valve. Hence the nodes recall the stronger internal prongs of *Eoleperditia*, where they likewise occur in the right valve only and plausibly were concerned with closure of the valves. At the same time it must be remembered that whereas in *Eoleperditia* the right valve is decidedly larger than and overlaps the left, in *Isochilina ottawa* the valves are approximately equal.

A second, newly recognized feature of *Isochilina ottawa* is the presence of subocular muscle-marks on the inner surface of each valve. These scars are very weak, and do not form an inner ridge. They consist of six or seven adjacent, vertically elongated spots placed side by side in a band or a very broad V. They hence appear prophetic of the

strong subocular V-mark of the Late Silurian isochilinid, *Dihogmochilina straitcreekensis*.

In the right valve, inner prongs like those that appear to take part in the closure of the valves in *Isochilina ottawa* are so far as yet known absent in post-Ordovician isochilinids. In *Dihogmochilina straitcreekensis* narrow flanges are downturned from the outer edge of the borders of the valves, and the flange of one valve probably lapped over that of the other valve, though it is not yet known which overlapped which.

A somewhat different manner of overlap occurs in *Isochilina jonesi* Wetherby (1881) of "Trenton" beds of Kentucky. In this species, the left valve has a marginal flange, broadest ventrally, that is overlapped by the bevelled edge of the right valve. *Jonesi* is relatively high in outline, and has a broad marginal border of isochilinid type. It is here placed in a new genus differing from *Isochilina* in the nature of the marginal overlap, and from *Dihogmochilina* in the weakness of surface sculpture as well as in presence of the strongly overlapped ventral flange.

PLAUSIBLE EVOLUTIONARY RELATIONSHIPS IN THE ISOCHILINIDS AND LEPERDITIIDS

So far as can be judged from present information, the isochilinid and leperditiid stocks had diverged from one another by the middle if not early part of the Ordovician, and subsequently underwent evolutionary changes which involved several interesting apparent parallelisms.

Isochilina and *Eoleperditia* of the Ordovician differ in the expanded valve-borders and essential valve-equality of the former, in contrast to the lack of borders and the strong valve-inequality in the latter. At the same time, they possess notable similarities in their comparatively large size; the fairly long straight hinge; the inequality of the ends wherein the plenate or posterior end is distinctly higher and more extended beyond the hinge than is the other, although the greatest thickness of the shell is antero-median; the antero-dorsal tubercle and corresponding internal pit, thought to have been the locus of the eye; the large antero-median adductor scar, composed of numerous, closely adjacent spots; the peculiar venose markings that radiate from the adductor scar and that commonly are structures of the internal shell layers, though they more rarely form external ridges; the relative thickness of the shell wall. In most of these features, the isochilinid and leperditiid stocks differed from the ostracodes proper; they were, however, Crustacea with bivalve shells, the valves closing without gape for protrusion of abdomen or other structures.

Beginning with *Isochilina*, first known in Early Ordovician, Beekmantown beds, the isochilinids continued into Silurian and Devonian time with seeming valve equality, and with the free margins of the valves expanded in flattened borders ventrally as well as terminally. The inner, right-valve prongs of *Isochilina ottawa*, apparently concerned with closure of the valves, are not known to have persisted beyond the Ordovician; instead, some isochilinids developed marginal, overlapping or at least overlapped, flanges. In *Dihogmochilina straitcreekensis*, a strong subocular, inner chevron-ridge is reflected by an external groove. Weak dorso-submedian furrows occur in some members, and small nodes may be developed. Few data are available about details of the hinge surfaces. The evolution of the currently reocgnized isochilinid genera may have taken place in about the fashion suggested in Table 1.

TABLE 1—Plausible evolutionary relationships of Isochilininae.

The inequivalved leperditiids begin with *Eoleperditia* in which, somewhat as in *Isochilina*, there are submarginal inner prongs that are restricted to the right valve, and subocular muscle marks that are small and weak, not chevron-like. The inner, right-valve prongs have not been recognized in

post-Ordovician species. Where the muscle marks have been studied in post-Ordovician forms, there is a distinct subocular chevron-mark that forms a ridge on the inner surface of the valve and that may be reflected by an external groove. The hinge surface is finely denticulate in Silurian and Devonian species in which the hinge detail has been investigated. Sulci and nodes are, in general at least, wanting. The generic evolution of the Leperditiids may have occurred in about the manner illustrated in Table 2.

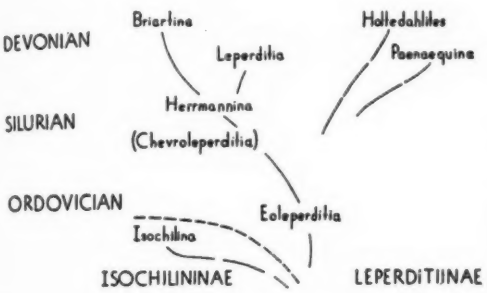


TABLE 2—Plausible evolutionary relationships of Leperditiinae.

The isochilinids and leperditiids are sufficiently distinctive in characters and as apparent evolutionary groups to deserve recognition as subfamilies, and hence the names Isochilininae and Leperditiinae are proposed for them.

LIST OF SPECIES

Family Leperditiidae Ulrich and Bassler
Subfamily Leperditiinae Swartz, n. subf.
Genus *Leperditia* Roualt
Leperditia scalaris Jones
Leperditia altiscalaris Swartz, n. sp.
Leperditia longigibbera Swartz, n. name
Genus *Herrmannina* Kegel
Herrmannina willsensis (Ulrich and Bassler)
Herrmannina welleri Swartz, n. name
Herrmannina (?) phaseolus (Hisinger)
Genus *Eoleperditia* Swartz, n. g.
Eoleperditia fabulites (Conrad)
Genus *Chevroleperditia* Swartz n.g.
Chevroleperditia chevronalis Swartz, n. sp.
Subfamily Isochilininae Swartz, n. subf.
Genus *Isochilina* Jones
Isochilina ottawa (Jones)
Isochilina venosculptilis Swartz, n. sp.
Genus *Hogmochilina* Solle
Genus *Teichochilina* Swartz, n. g.
Genus *Dihogmochilina* Teichert
Dihogmochilina straitcreekensis Swartz

Class OSTRACODA Latreille
Family LEPERDITIIDAE Jones

Paleozoic, bivalved Crustacea, provisionally classed as Ostracoda. Shells tend to be relatively thick-walled, and are comparatively large, ranging from about 5 to 20 mm. in length, or rarely to 30 mm. and more; hinge line is straight, fairly long, with both cardinal angles well defined; closure is complete, without marginal gapes or incisions; near the anterior or antiplenate* cardinal angle is an inner pit and commonly a corresponding external tubercle, thought to have been the locus of the antero-lateral eye; adductor scar lies antiplenately to the mid-length; it generally is well-marked, large, suboval, and consists of numerous, closely spaced though discrete spots; venose lines radiate from the adductor scar; fundamentally, the adductor scar and venose markings are features of the inner portion of the valve-wall, but the scar and more rarely the venose markings may be reflected externally; surface of valve commonly smooth, without distinct lobes, sulci, ridges, or furrows, though ornament is fairly strong in a few genera.

Subfamily LEPERDITIINAE Swartz, n. subf.

Inequivalved Leperditiidae, generally with right valve overlapping the left, especially in the ventral region. Flattened borders may be developed terminally, but do not continue along the ventral margin.

* The writer (Swartz 1945a) has suggested that the fuller and more extended end of the ostracode shell may conveniently be termed the plenate end, especially in Paleozoic groups where disagreements exist about anterior-posterior orientations.

Genus LEPERDITIA Rouault, 1851

Leperditiinae having a strong swelling adjacent to posterior part of hinge in left, or right-plenate valve, but not in the right valve. Below the distinct eye tubercle is a chevron-like muscle mark, its detail comparable to that of the larger adductor scar. The North American species, *Leperditia scalaris* Jones, has a finely denticulate hinge; a shoulder on the inner margin of the overlapped flange of the left valve served as a stop for the edge of the right valve; both of these features should prove to be generic characters for *Leperditia* in the restricted sense here used. The longitudinal axis of the shell is oblique to the hinge; the surface of the valve is not sulcate and is nearly if not quite devoid of fine ornament.

Genotype.—Leperditia britannica Rouault.

Relationships.—Leperditia is here employed in the greatly reduced sense proposed by Kegel (1932) for *Leperditia* as the typical subgenus of *Leperditia* sensu lato. It is especially close to *Herrmannina* Kegel (1934), *Eoleperditia* Swartz, n. g., and *Chevroleperditia* Swartz n. g. It is distinguished from all three of these genera by the distinct swelling adjacent to the posterior part of the hinge in the left but not the right valve. The subocular chevron-mark is absent in *Eoleperditia; Eoleperditia* and *Chevroleperditia* both lack the denticulation of the hinge that occurs in *Leperditia scalaris.*

With restriction to species having postdorsal left-valve swellings like that of *L. britannica, Leperditia* includes at least the following forms: *L. britannica* Rouault (1851); *L. gibbera* Jones (1856); *L. guelphica* Jones = *L. balthica* var. *guelphica* Jones (1891); *L. kotelnyensis* von Toll (1890); *L. longigibbera* Swartz, n. name = *L. hisingeri* var. *gibbera* Jones (1891), not *L. gibbera* Jones (1856); *L. scalaris* Jones (1858); *L. tyracia* Schmidt (1873); and *L. altiscalaris* Swartz, n. sp. Most of the other species that have been referred to *Leperditia* will prove to belong in *Herrmannina* and *Eoleperditia,* with some in *Chevroleperditia* and *Briartina.*

Occurrence—The recognized species of *Leperditia* sensu stricto occur in the Silurian and Devonian of Europe, the Middle and Late Silurian of North America.

LEPERDITIA SCALARIS Jones
Plate 65, figures 3–10

Leperditia gibbera var. *scalaris* JONES, Ann. Mag. Nat. Hist., ser. 3, 1 (1858), p. 250, pl. 10, figs. 10, 11.

Leperditia scalaris BASSLER and KELLETT, Geol. Soc. America Special Papers, No. 1 (1934), p. 399.—SWARTZ, Penna. Geol. Survey, 4th series, Bull. G 19 (1939), pl. 1, figs. 15a–c.—SHIMER and SHROCK, Index Foss. North America (1944), pl. 280, figs. 5–8.

Shell elongate, the ratio of length to height variable but commonly about 1.6 or 1.7 to 1; hinge straight, two-thirds or slightly more of greatest length; cardinal angles moderately prominent; posterior end broadly rounded, fullest below. Anterior end is distinctly lower than the other, and has a sharply rounded subangulation slightly above the midheight; above this subacumination the margin is relatively straight and truncate; below it, the margin curves obliquely backwards toward the position of greatest height which is about one-third distance from the posterior end.

Hinge surface, as observed in specimens obtained from base of Keyser limestone at Shoupe's quarry near Loysville, Pennsylvania, and from Decker limestone in New Jersey, is finely denticulate; in a specimen from Shoupe's quarry, there are 11 denticles in 1 mm. Right valve overlaps left along free margins, the overlap being slight terminally, stronger ventro-medially. Overlapped edge of left valve forms a flange, broadest ventro-postmedially; at the proximal margin of the flange there is a well-defined shoulder that acted as a stop for the overlapping edge of the right valve; the line of the shoulder is somewhat sinuous, as viewed ventrally, in accordance with the variable overlap.

Surface of valve moderately convex, with greatest convexity about two-fifths from anterior end. Eye tubercle, low but distinct, is one-third or slightly more of distance from dorsal margin, slightly less than one-third distance from anterior end. Flattened borders, somewhat broader on the right valve, occur in the upper to middle parts of the terminal margins but fail ventrally. A well-defined, elongate swelling parallels the more posterior part of the dorsal margin in the left valve, but is not appreciably represented in the right valve. The surface, where excep-

tionally well preserved, bears minute, widely spaced granules.

The muscle scars, and the venose lines radiating from the adductor scar, do not usually affect the external surface of the valve, but may be seen from the exterior if the shell remains reasonably translucent and is treated with water or oil. Adductor scar is ovate, subacuminate above, and consists of 50 to 60 spots of irregular size and shape. Below eye tubercle is a chevron-mark, leaving a shallow groove on internal molds; the extremities of the limbs do not reach the level of the eye tubercle. Muscle spots occur in the area enclosed by the limbs of the chevron-mark, and minute spots form about nine groups in the anterodorsal part of the valve, in the fashion detailed in accompanying camera lucida sketches.

A left valve measures length 11 mm., height 6.2 mm.

Relationships.—The specimens here illustrated from the Decker limestone of New Jersey, like those figured previously from the Keyser limestone of Pennsylvania (Swartz, 1939), differ from *scalaris* as originally drawn by Jones (1858) from the Akron limestone of Williamsville, New York, in the subacumination of the anterior outline and consequent subtruncation of the margin about it. Jones' sketch of the muscle scars shows the V-mark with limbs less divergent than in the writer's material, and reaching closer to the eye tubercle.

If these differences are confirmed by reexamination of the holotype and topotypes, then the Keyser-Decker material will need to be considered a distinct species. In view of the care with which Jones figured valve outlines, the difference in anterior curvature may well exist.

Occurrence.—The material illustrated on accompanying plates comes from loose pieces of Decker limestone, apparently from the middle part of the formation, at the southeastern foot of Wallpack ridge about a quarter-mile north of the small William Nearpass quarry in New Jersey and about 2½ miles south of Port Jervis, New York. The species is abundant in the basal beds of the Keyser limestone at numerous localities in central Pennsylvania (Swartz, 1939), and specimens have been obtained by the writer in the lower 20 feet of the Keyser at Keyser, West Virginia. *Scalaris* is also locally present in central Pennsylvania in layers that seem to represent uppermost Tonoloway limestone.

LEPERDITIA ALTISCALARIS Swartz, n. sp.
Plate 65, figures 11–13

Shell subovate, relatively high in outline, truncated dorsally by the straight hinge which extends for about two-thirds of greatest length. The holotype left valve has a ratio of length to height of about 1.43 to 1; in an associated right valve that is elongate for the species, the ratio is about 1.55 to 1. Cardinal angles well defined, the posterior angle especially having a subjacent emargination. Posterior margin broadly rounded, extending beyond hinge about a seventh to an eighth of valve length. Anterior margin more narrowly curved, especially near midheight, above which the margin is more or less truncate. Ventral margin obliquely convex, the greatest height being about two-fifths of distance from posterior terminus.

Hinge and overlap not determined.

Surface of valve moderately convex; maximum convexity anterior to and slightly below center of valve. Eye tubercle not conspicuous externally. Well-defined borders extend along the terminal margins but fail ventrally. Swelling along posterior part of hinge of left valve is moderate in size and elevation. Fine detail is not shown on studied specimens.

Internal molds reflect a well-developed eye-pit. There is a distinct internal, subocular chevron-ridge, the posterior limb flexuous, longer than the anterior one; the adductor scar is subovoid, subacuminate above.

The holotype left valve measures length 8 mm.; height 5.4 mm.

Relationships.—*Leperditia altiscalaris* is a close relative of *scalaris* itself, but differs in the comparatively greater height of the shell, the ratio of length to height being about 1.4 or 1.55 to 1, as compared to a common 1.6 or 1.7 to 1 in *scalaris* as represented in the Decker limestone in New Jersey and the basal Keyser of central Pennsylvania, and 1.63 to 1 in Jones' original figure for the species. This change in proportions is given increased significance by the difference in stratigraphic position.

Occurrence.—Common in late Silurian Rondout limestone, at base of horizon A-15 of Weller's (1903) section, William Nearpass quarries, southeastern slope of Wallpack Ridge, New Jersey, about 2¼ miles south of Port Jervis, New York.

LEPERDITIA LONGIGIBBERA Swartz, n. name

Leperditia hisingeri var. *gibbera* JONES, Contr. Can. Micropaleo., Pt. III (1891), p. 82, 83, pl. 13, fig. 4. Not *Leperditia gibbera* JONES, Ann. Mag. Nat. Hist., ser. 2, vol. 17 (1856), p. 90, pl. 7, figs. 8–10.

Shell as illustrated by Jones is elongate-subovate, truncated dorsally by hinge which is about two-thirds of greatest length. Ratio of length to height is nearly 2 to 1. Cardinal angles well defined, with slight subjacent emarginations. Posterior margin rounded, most extended submedially, projecting beyond hinge about two-sevenths of length of valve. Anterior margin lower, fullest ventrally. Ventral margin nearly straight but diverging from hinge for more than half of length of valve, then convexly curved in its more posterior part.

Details of hinge and overlap not known.

Flattened borders are weakly developed along the terminal margins. Eye tubercle distinct. Adductor scar is antero-median in location, and is discernible externally. An elongate, dorsal thickening or swelling extends in left valve for most of length of hinge.

The holotype, Jones' figured specimen, measures about length 5.6 mm., height 3.1 mm.

Relationships.—*L. longigibbera* was compared by Jones (1891) with *L. kotelnyensis* von Toll (1889) with the statement that the former "is much smaller, more oblique on the ventral margin, and has a relatively shorter hingeline, and the dorsal thickening is longer and more distinct."

In *Leperditia gibbera* Jones (1856) the outline is different, and the post-dorsal swelling of the left valve is stronger but shorter, extending for less than a third of the length of the valve.

Occurrence.—Silurian beds, Long Point, northeast side of Lake Winnipegosis, Canada. Jones stated that the containing strata overlie "several hundred feet of Niagara limestone."

Genus HERRMANNINA Kegel, 1933

Leperditiidae with longitudinal axis oblique to hinge; contact surface of hinge is finely denticulate in a taxodont-like manner; a subocular chevron-mark is present; there is no appreciable development of a post-dorsal swelling in the left valve.

Genotype.—*Herrmannella waldschmidti* Paeckelmann.

Relationships.—The generic name, *Herrmannella*, was used by Paeckelmann (1922) for the *Leperditia*-like, Middle Devonian species, *H. waldschmidti* Paeckelmann, because it was discovered that the hinge is finely denticulate in a taxodont-like fashion. Kegel (1933) subsequently recognized that denticulation of this type had earlier been figured by Barrande (1872) in *Leperditia baltica*, and by Kolmodin (1879) in *L. phaseolus;* actually, it had likewise been illustrated by Jones (1891) in specimens identified as *L. hisingeri* and *L. alta*. Kegel's investigations showed that the hinge is denticulate in some of the species that he described as new, as well as in *L. consobrina* Jones.

Denticulation of the hinge thus had been found in a considerable number of species of *Leperditia*-type. Kegel concluded that the denticulation occurs in all the leperditiids in which the hinge detail had been worked out, and further that such denticulation was not proven to be satisfactory for separation of *Herrmannella* from *Leperditia*, since denticulation might well exist in the uninvestigated hinge of the *Leperditia* genotype, *L. britannica* Rouault.

Though he could not confirm the separation of *Herrmannella* from *Leperditia* on the basis of hinge characters, Kegel did conclude that *Herrmannella* deserves recognition as a subgenus of *Leperditia*, since *waldschmidti* lacks the peculiar post-dorsal swelling that is conspicuous in the left valve of *L. britannica*. Kegel (1934) subsequently discovered that the name *Herrmannella* is preoccupied by *Herrmannella* Canu (1891) of the Copepoda, and proposed *Herrmannina* for the leperditiid group.

The present investigation has shown that a denticulate hinge occurs in *Leperditia scalaris*, which has a post-dorsal swelling like that of *L. britannica* and hence is thought to belong in *Leperditia* in its strictest sense. Although hinge denticulation thus seems to

fail as a means for separation from *Leperditia*, it appears desirable to the writer to regard *Herrmannina* as a valid group on the basis proposed by Kegel. *Herrmannina* is here treated as a distinct genus; its retention in *Leperditia* as a subgenus may prove preferable for common usage.

Occurrence.—Species of *Herrmannina* are common in the Middle Devonian of Germany, and in Middle and Late Silurian beds in Europe and North America. It is not certain that any of the known Ordovician leperditiids have denticulate hinges.

HERRMANNINA WILLSENSIS (Ulrich and Bassler)
Plate 66, figures 11, 12

Leperditia elongata var. *willsensis* ULRICH and BASSLER, Md. Geol. Survey, Silurian (1923), p. 500, pl. 36, figs. 3–6.

Photographs of the internal mold of a left valve from the Silurian of Virginia, are given in an accompanying plate to illustrate the taxodont-like character of the hinge margin of *willsensis*. The matrix is a fine-grained sandstone, but the impressions of the minute, uniformly sized and spaced denticles of the hinge surface are finely preserved. The mold of the eye-pit of the inner surface of the valve is discernible; the furrow left by the subocular chevron-mark is poorly displayed; the impression of the adductor scar is obscure. The mold shows no trace of the post-dorsal, left-valve swelling of *Leperditia*.

The comparative height of the valve is greater than is typical for the species. The specimen measures length 7.5 mm., height 5 mm.

Occurrence.—The figured specimen is from the late Silurian Wills Creek formation, Marcus O'Neal farm 1.6 miles north of Seven Fountains, Massanutten Mountain area, Virginia.

HERRMANNINA WELLERI Swartz, n. name
Plate 65, figures 14, 15

Leperditia gigantea WELLER, Geol. Survey, N. J., Pal., vol. 3 (1903), p. 260, pl. 23, fig. 14.—Not *Leperditia gigantea* ROEMER, Deutsch. Geol. Ges., Zeitschr. 10 (1858), p. 357, text figs. 1–3, p. 360 = *Leperditia grandis* (*Cypridina grandis* Schrenk, 1853).

Shell large; dorsally truncated subovoid to almost subelliptical in outline, the height about two-thirds or slightly more of length, the hinge about three-fifths of length. Cardinal angles obtuse, not prominent, the posterior angle especially being weak for the genus. Posterior margin almost semicircular, extending beyond hinge about one-sixth of valve length. Anterior end slightly lower than posterior, and extending almost as far beyond hinge, its curvature comparatively regular. Ventral margin gently convex, the posteriorward divergence from the hinge moderate.

Valve moderately convex, reaching its maximum about one-third distance from anterior end and slightly below midheight. Weakly defined, comparatively narrow borders extend along the terminal margins but fail ventrally. Ventral margin of right valve is turned under and overlaps left valve in the the leperditiid manner. Eye tubercle distinct, lying about one-seventh distance below dorsal margin and one-quarter or more distance from anterior end. Behind eye tubercle and slightly anterior to midlength of hinge, there is a faint, subvertical depression which extends from the hinge for about a quarter of the distance to the ventral margin.

Below eye tubercle is a well developed chevron-mark, its limbs forming an angle of about 70 degrees and not reaching to the level of the eye tubercle; within the limbs of the chevron-mark are other muscle spots. Adductor scar, posterior to chevron-mark, is ovate in outline, acuminate above, and consists of about 70 to 80 constituent spots. Between adductor scar and eye tubercle is a small group of muscle spots, and dorsal to the eye tubercle about six additional groups are present, their detail in a favorably preserved valve being shown in an accompanying camera lucida sketch.

Surface of valve smooth or very nearly so.

The specimen figured by Weller (1903) measures about length 22.5 mm., height 14 mm., convexity 6 mm. The largest specimen in the writer's collection measures length 14.5 mm., height 10.5 mm.; the figured muscle pattern is sketched from a right valve measuring length 10 mm., height 7 mm.

Relationships.—Because Roemer used the term, *Leperditia gigantea*, in 1858, it is the writer's understanding that *Leperditia gigantea* Weller 1903 must be treated as a

homonym, even though *gigantea* Roemer is currently regarded as a synonym of *Leperditia* (*Herrmannina?*) *grandis* (Schrenk, 1854). Accordingly, the new name, *Herrmannina welleri*, is proposed for the species described by Weller.

Welleri is illustrated in the present paper because one of the specimens in the writer's collections exhibits the muscle spots in excellent detail. Venose markings radiate from the adductor scar, but no attempt was made to show them in the accompanying camera lucida sketch. *Welleri* lacks the post-dorsal left-valve swelling of *Leperditia* proper, and hence is here classed in *Herrmannina*.

Occurrence.—The writer's specimens of *Herrmannina welleri* come from the Rondout limestone, at the William Nearpass quarries at the southeastern foot of Wallpack Ridge, New Jersey, about 2¾ miles south of Port Jervis, New York. They occur 5½ feet below the "Pethstone" bed of Weller's (1903) description, at top of his bed A 17.

EXPLANATION OF PLATE 65

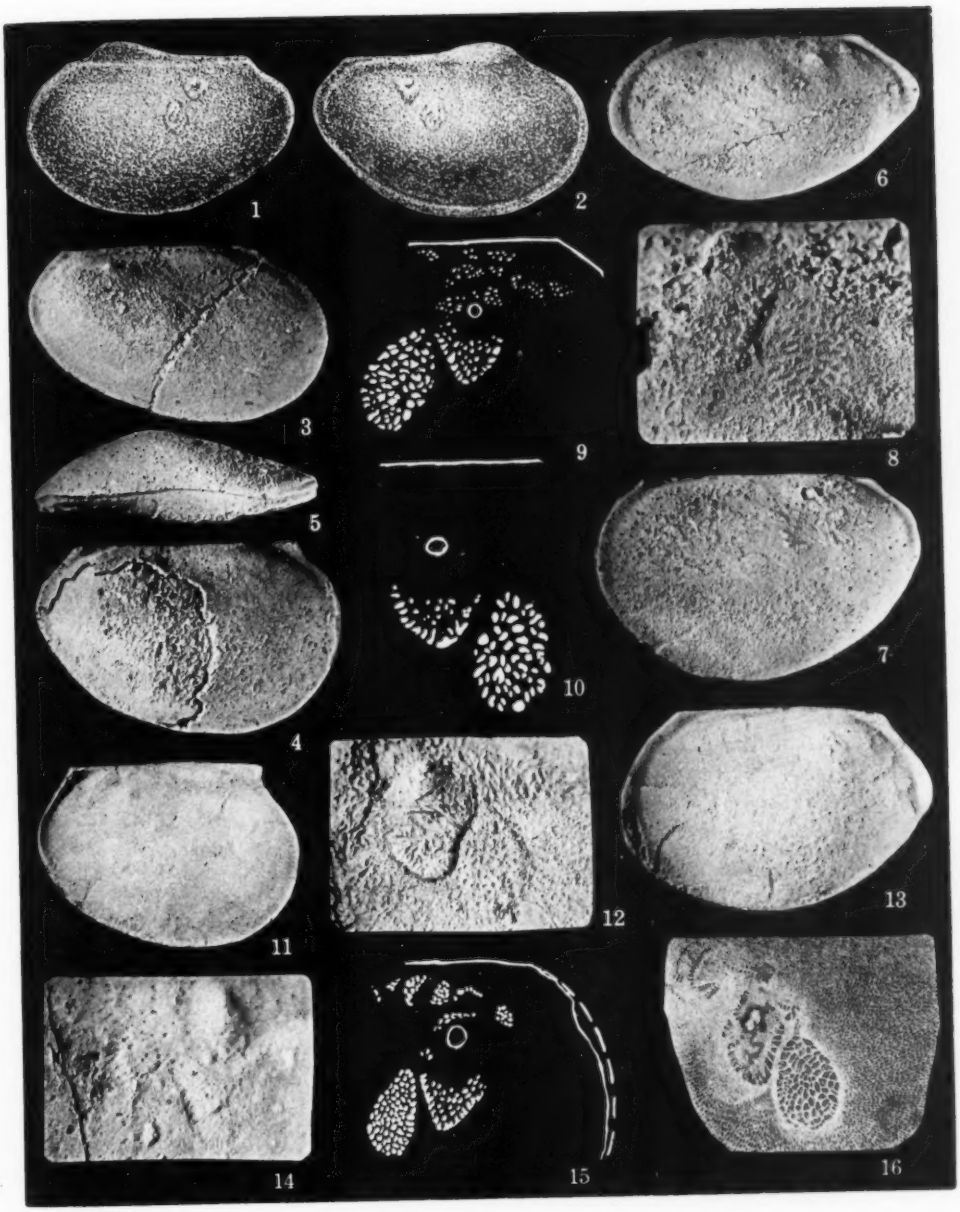
FIGS. *1, 2*—*Leperditia britannica* Rouault. Right and left sides of a shell, as figured by Oehlert (1851), here increased to a magnification of about ×3½. The eye tubercle, subocular V-mark, adductor scar, strong post-dorsal swelling of the left valve, strong overlap of right valve on the left, are all clearly visible. The specimen came from the Devonian of France and was described under the heading "Fossiles du calcaire et du schist Devonien." Reported localities: Gahard, Izé. (p. 312)

3–10—*Leperditia scalaris* Jones. *3–5*. Lateral views of two left valves, and ventral view of a third, all ×4. The lateral views illustrate the general range in proportions of the shell, but the full strength of the post-dorsal swelling is not apparent. In *5*, note the antero-median location of the point of greatest convexity, as well as the low shoulder that defines the inner edge of the overlapped flange, and that served as a stop for the edge of the right valve. *6, 7*. Views, ×4, of two right valves, showing the flattened borders of the terminal margins, and extremes in outline. *8*. Part of internal mold of a left valve, about ×10, showing mold of the eye-pit, impressions of the subocular V-mark and adductor scar. *9*. Camera lucida sketch, ×8, of the adductor scar, the subocular V-mark with its enclosed spots, and the groups of scars dorsal to the eye tubercle, as observed in a valve coated with oil. The eye tubercle is indicated by a small circle. *10*. Camera lucida sketch, ×8, of the adductor scar and subocular V-mark of a left valve, in which the more dorsal, small spots are not readily seen. The figured spots are however especially clear, and their detail is more nearly correct than in figure *9*, where there is some generalization. In both of these sketches, the venose lines radiating from the adductor scar have been omitted, though they are visible in the specimens. *3–8:* Loose from late Silurian, Decker limestone, southern foot of Wallpack Ridge, just west of lane on Dalton Nearpass farm, in New Jersey about 2½ miles south of Port Jervis, New York. *9:* Basal part of late Silurian Keyser limestone, north outskirts, Bedford, Bedford County, Pennsylvania, on east side of road to Altoona. *10:* About 5 feet above base of late Silurian Keyser limestone, south limb of anticline just north of Selinsgrove Junction, on east side of Susquehanna River, Northumberland County, Pennsylvania. (p. 312)

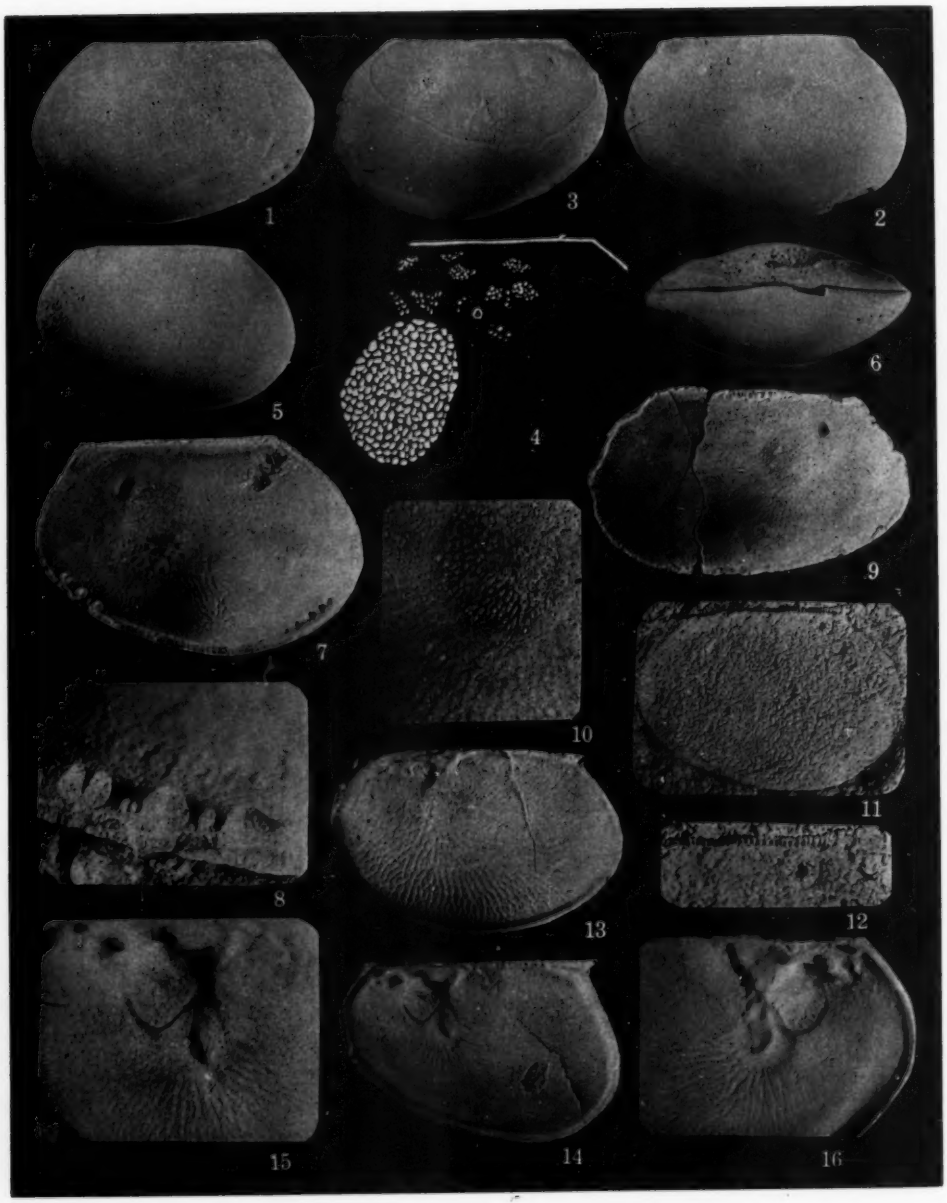
11–13—*Leperditia altiscalaris* Swartz, n. sp. *11*. View, ×5, of holotype left valve, showing the short and high outline characterizing the specimens from the type horizon. The lighting does not properly emphasize the post-dorsal swelling. *12*. View ×10, of part of internal mold of another, larger left valve showing mold of eye-pit, and impressions of the subocular V-mark and the adductor scar. The valve measures length 10 mm., height 7 mm. *13*. View, ×5, of a comparatively elongate right valve. This valve is not much higher, relatively, than is the right valve of *Leperditia scalaris* shown in figure *7;* but that valve represents an extreme in height of associated specimens which range in proportions to the elongate valve in figure *6*. Late Silurian Rondout limestone, base of horizon A15 of Weller's (1903) section, William Nearpass quarry, southeastern slope of Wallpack Ridge, New Jersey, about 2¾ miles south of Port Jervis, New York. (p. 313)

14, 15—*Herrmannina welleri* Swartz, n. name. View, ×12, of part of external surface of a right valve, showing eye tubercle and external reflection of V-mark, and camera lucida sketch, ×8, of the same, showing details of the scars visible when the specimen is coated with oil. Late Silurian, Rondout limestone, 5½ feet below "Pethstone" bed, at top of 2 A 17 of Weller's section, William Nearpass quarry, Wallpack Ridge, New Jersey. (p. 315)

16—*Herrmannina* (*?*) *phaseolus* (Hisinger). Sketch published by Kolmodin (1879), showing with unspecified enlargement the subocular V-mark, the adductor scar with the radiating venose lines, and traces of the scars dorsal to the eye tubercle. Silurian of Gotland. (p. 317)



Swartz, Structures of Leperditiidae



Swartz, Structures of Leperditiidae

HERRMANNINA (?) PHASEOLUS (Hisinger)
Plate 65, figure 16

Cytherina phaseolus HISINGER, Bidrag till Sveriges Geognosie (1831), pp. 110–135, pl. 8, fig. 3;—Lethaea Svecica (1837), p. 9, pl 1, fig. 1.

Leperditia phaseolus KOLMODIN, Ofv. Kan. Vet.-Akad. Förhandl., vol. 36 (1879), p. 134, pl. 19, figs. 4a–e, 5a, b.

Kolmodin's (1879) sketch of the muscle scars of *phaseolus* is here figured because of the excellent detail with which it depicts the adductor and subocular chevron mark of this European species. The muscle scar groups dorsal and antero-dorsal to the eye tubercle are probably generalized, as are the venose markings radiating from the adductor scar.

It is very interesting that the number of constituent spots in the adductor scar falls within the range of 60 to 80 as is true in the North American *Leperditia scalaris* and *Herrmannina welleri*, whereas there are about 200 of these constituent spots in *Eoleperditia fabulites* of the Ordovician.

The measurements for *H. (?) phaseolus* given by Kolmodin are length 13 mm., height 7 mm.

Occurrence.—Silurian of Gotland.

Genus EOLEPERDITIA Swartz, n. g.

Thick shelled, essentially smooth surfaced Leperditiinae that possess a few small muscle-spots but no chevron-mark below the eye tubercle, lack any appreciable development of a post-dorsal swelling in the left valve, and have a non-denticulate hinge. A number of prongs, placed on the inner surface of the right valve near either end of the ventral margin, evidently served as stops for the edge of the overlapped left valve.

The right valve overlaps the left along the terminal and especially the ventral margins; the longitudinal axis is oblique to the hinge; the antero-dorsal, presumed eye tubercle may be weak externally, but is represented on the inner surface of the valve by a distinct pit; the adductor scar is round to ovate, the constituent spots numerous, and has venose markings radiating from it; groups of minute muscle spots occur in area above and anteri-

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EXPLANATION OF PLATE 66

FIGS. *1–10—Eoleperditia fabulites* (Conrad), Swartz, n. g. *1, 2.* Right and left valves, ×3½, showing the small, antero-dorsal eye tubercle and, in *1*, the ventro-terminal pits corresponding to the internal prongs illustrated in figures *7, 8. 3, 4*—A right valve, ×3½, the upper portion slightly weathered, and a camera lucida sketch of its muscle scars, ×7, prepared with the surface coated with oil. In figure *3*, note the post-median prominence of the ventral margin. *5*—A small right valve, ×3½. As in figure *2*, the ventral margin of the left valve lacks the post-median prominence of the right. *6*—Ventral view of a shell, ×3½, the left valve imperfect. *7, 8*—Interior of a large right valve, ×3½, and further enlargement, ×12, of its antero-ventral prongs. The well-preserved hinge surface of this specimen has a very faint longitudinal groove. *9, 10*—Interior of a left valve, ×5, and part of the same, ×12, showing the adductor scar, the radiating venose lines, and the sharp pit corresponding to the weak, external eye tubercle. *1–6:* Ordovician, upper part of Lowville limestone, St. Josephs Island, Ontario, at northwestern end of Lake Huron. United States National Museum, No. 467 B. *7, 8:* Ordovician, Glade limestone, High Bridge, Kentucky. United States National Muserum collections. *9, 10:* Ordovician, Lebanon limestone, Lebanon, Tennessee. United States National Museum, No. 41267. (p. 318)

11, 12—Herrmannina willsensis (Ulrich and Basler). Internal mold of a left valve, ×5, preserved in a fine-grained sandstone, and part of the impression of the hinge, ×10. The taxodont-like hinge dentition is clearly reflected; the mold of the eye-pit, and the groove left by the subocular V-mark are more obscure. Late Silurian, Wills Creek formation, 1.6 miles north of Seven Fountains, Massanutten Mountain area of Virginia. (p. 315)

13—Isochilina venosculptilis Swartz, n. sp. The holotype left valve, ×8, showing the strongly elevated, venose lines of the external surface. Ordovician, Pamelia limestone, 1 mile north of Aylmer, Quebec, Gift of G. Winston Sinclair. (p. 323)

14–16—Dihogmochilina straitcreekensis Swartz. *14, 15.* View, ×5, of holotype, a nearly perfect left valve; and part of surface of same, ×10½, showing the eye tubercle, the subocular V-groove, the adductor scar at the hub of the radiating, venose lines, and the pits dorsal and anterior to the eye tubercle. *16*—An incomplete right valve, ×5; this is the largest observed specimen, its length restored being about 14 mm., as compared to a length of 8½ mm. for the holotype. Late Silurian, Tonoloway limestone, at Strait Creek, 6½ miles north of Monterey, Virginia. (p. 326)

or to the eye tubercle. Surface is not sulcate, and fine ornament inconspicuous. The genotype lacks borders along the terminal margins.

Genotype.—Cytherina fabulites Conrad, 1843.

Relationships.—Eoleperditia as here described differs from the related *Leperditia* and *Herrmannina* in a number of important features; but further work will have to show whether the evolutionary changes of these structures take place together or independently of one another.

In contrast to both *Leperditia* and *Herrmannina, Eoleperditia* lacks a subocular chevron mark, has a non-denticulate hinge, and has ventro-terminal inner prongs in the right valve that acted as stops for the edge of the overlapped left valve. Like *Herrmannina*, it lacks the post-dorsal, right valve swelling of *Leperditia*. In *Eoleperditia fabulites*, the adductor scar consists of some 200 constituent spots, whereas there are about 60 to 80 in *Leperditia scalaris*, in *Herrmannina welleri*, and in *H. phaseolus* as figured by Kolmodin. Lack of terminal borders may also prove generically significant in *Eoleperditia* as compared to *Leperditia* and *Herrmannina*.

Leperditia groenlandica Teichert (1937) and *L. catheyensis* Kirk (1928), from Ordovician beds of Greenland and Tennessee, respectively, have external, ventro-terminal pits in the right valve that evidently reflect inner prongs of eoleperditiid type. These species can be placed in *Eoleperditia* along with *fabulites*, although investigation of their hinge and muscle scar structures is needed. Renewed studies of additional Ordovician Leperditiinae may add considerably to the membership of *Eoleperditia*.

In *Anisochilina punctulifera* Teichert (1937), used as the type of its genus, the general outline, character of cardinal angles, extension of the terminal margins beyond the limits of the hinge, and finally the lack of terminal submarginal borders, are all reminiscent of *Eoleperditia fabulites*.

Anisochilina was regarded by Teichert as comparable to *Isochilina* because of apparent external equality of the valves. The left valve, however, has a broad flange that is overlapped by the edge of the right valve. Unfortunately, *Anisochilina punctulifera* is known from a single left valve; the inequality in size of the two valves is not known, though judging from Teichert's (1937, pl. 22, fig. 11) ventral view of the holotype specimen the ventral part of the right valve probably projected slightly beyond the general plane of commissure of the valves; the nature of the hinge and of the muscle scars has not been determined; finally, lacking the right valve, it is not known whether there are external pits and internal prongs near the terminal parts of the ventral margins. A second species, *Anisochilina undulata* Teichert (1937a) is a small, somewhat questionable member of this "genus" and is likewise represented by a single left valve.

Because of the deficiencies in knowledge of the characters of *punctulifera*, it is difficult to make use of *Anisochilina*. I the right valve has eoleperditiid prongs, then *punctulifera* does not at all have the relationships that Teichert had in mind in proposing *Anisochilina*. In any event, because of its lack of flattened marginal borders, *A. punctulifera* will in the writer's opinion find its relationships among the leperditiids and not the isochilinids as was Teichert's supposition.

Occurrence.—The known occurrences of *Eoleperditia* are in Middle Ordovician deposits in middle and eastern parts of the United States and southern Canada, and in the Ordovician of northern Greenland.

EOLEPERDITIA FABULITES (Conrad)
Plate 66, figures 1–10

Cytherina fabulites CONRAD, Acad. Nat. Sci. Philadelphia, Pr., vol. 1 (1843), p. 332.
Leperditia fabulites JONES, Ann. Mag. Nat. Hist., ser. 2, vol. 17 (1856), p. 89.—BASSLER and KELLETT, Geol. Soc. America, Special Papers, No. 1 (1934), p. 384.

Shell subovate in outline, truncated dorsally by straight hinge which extends for about three-fifths of greatest length. Cardinal angles subequally obtuse, moderately prominent, not set off by subjacent emarginations. Posterior margin broadly rounded, extending beyond hinge about one-sixth of the valve length, fullest slightly below midheight. Anterior margin distinctly lower than the posterior, tending to be subtruncate in its upper part, then curving more sharply near the midheight of the valve. Ventral margin convex, diverging from hinge posteriorly; curvature of ventral

margin, and hence position of greatest height, differs in the two valves; in right valves the position of greatest height is slightly post-median, and curvature of ventral margin at this place is in many valves rapid enough to produce a broad subangulation; in left valves the greatest height is more posterior in location, and though the curvature is less gentle posteriorly than anteriorly, there is no tendency toward a post-median subangulation.

Hinge surface moderately broad in right valve, not denticulate but having a very faint longitudinal groove. Hinge edge of other valve is narrower in a small specimen, but its character in large examples is not determined. Valves unequal, the right valve larger than and overlapping the left along the free margins, the overlap greatest ventrally, where the underturned edge of the right valve has a gentle median, lip-like projection. Overlapped part of underturned edge of left valve not very sharply set off from remainder of valve, its inner margin not defined by a shoulder.

Surface of valve moderately convex, the greatest convexity tending to be slightly antero-median in location. Surface descends to the margins without borders terminally or elsewhere. Eye tubercle obscure, located about one-fifth distance below dorsal margin, about three-tenths distance from anterior extremity. Near each end of the ventral margin there are in the right but not the left valve four to six small pits; these are the external reflections of prongs of the inner surface that apparently served as stops for the edge of the overlapped left valve. External surface smooth.

On inner surface of valve, the external eye tubercle is reflected by a well-defined eye pit, the depth showing that the valve wall is decidedly thinned at the summit of the tubercle. Post-ventral to the eye pit is a large, subovoid but not acuminate adductor scar, the constituent spots numerous, irregular in shape and distribution though subequal in size; there are nearly 200 of these spots in the best-observed adductor scar; the detail of the spots can best be seen through the external, wetted surface of the valve. Radiating from the adductor there are on the inner surface of the valve irregularly forking, venose lines; these are not reflected on the exterior of the valve, but can be observed through the wetted surface.

Muscle spots other than the adductor have not been detected on the inner surfaces of the studied valves; but with proper treatment of the exterior, there can be seen a series of groups of tiny spots; one group of five to eight spots is found antero-ventral to the eye tubercle but shows no resemblance, other than location and muscle-scar nature, to the chevron marks of members of *Leperditia* and *Herrmannina*. More or less dorsal to the eye tubercle are eight or nine additional groups of tiny spots. The detail where best shown in a slightly weathered valve, is approximated in the accompanying camera lucida sketch.

A representative right valve measures about length 13 mm., height 8.5 mm. An exceptionally large right valve measures about length 15 mm., height 10 mm.

Relationships.—Eoleperditia fabulites has commonly been used to exemplify *Leperditia* but differs strikingly from *Leperditia britannica* in lack of the subocular chevron-mark. and presence of the ventro-terminal external pits and corresponding internal prongs. The non-denticulate hinge and large adductor scar with its numerous constituent spots are significant features, and lack of terminal, marginal borders may also prove to have generic significance.

Eoleperditia groenlandica (Teichert, 1937a) is a close relative of *E. fabulites*, but the greatest fullness of the posterior margin is more ventral in location, and the bend to the underturned marginal part of the right valve is more angular.

Occurrence.—The types of *Eoleperditia fabulites* came from Middle Ordovician beds of St. Josephs Island, Canada. The topotype examples from the upper part of the Lowville limestone of this island, that are figured on accompanying plates, were loaned for the present study by the United States National Museum through the courtesy of Dr. R. S. Bassler. Additional specimens, loaned from the same source, came from the Lebanon limestone, Lebanon, Tennessee, and from the Glade limestone, at High Bridge, Kentucky.

Genus CHEVROLEPERDITIA Swartz, n. g.

Leperditiinae having a downwardly convex, chevron-like muscle mark ventral to the eye tubercle; the hinge surfaces are not

denticulate; there is no distinct swelling in the left valve adjacent to the posterior part of the hinge. The chevron-mark tends to form a ridge on the inner surface of the valve, so that it leaves a groove on the internal mold. Overlap along the free margins is not fully understood, but the right valve probably overlaps strongly on the left along the ventral margin. The surface of the valve is non-sulcate, essentially smooth except for the eye tubercle. The valve wall is thick.

Genotype.—Chevroleperditia chevronalis Swartz, n. sp.

Relationships.—Chevroleperditia as here proposed differs from *Leperditia* proper in lack of denticulation of the hinge surfaces, and in absence of the post-dorsal swelling of the left valve that characterizes species of the latter group. It closely resembles *Herrmannina* except for lack of denticulation of the hinge. Like *Eoleperditia* the hinge is nondenticulate; but the chevron-mark is strongly developed as in *Leperditia* and *Herrmannina*, and the inner prongs of the right valve of *Eoleperditia* seem to be lacking.

Occurrence.—The genotype and only known example of *Chevroleperditia* is found in mid-Paleozoic shales beneath Cretaceous sediments at the bottom of the Warren Chandler No. 1 well, Early County, Georgia.

CHEVROLEPERDITIA CHEVRONALIS
Swartz, n. sp.
Text figures 1, 2

Shell moderately large; lateral outline subovate, truncated dorsally by the straight hinge which is about three-fifths of greatest length; both cardinal angles are sharply defined, the posterior or adplenate angle being especially prominent because of indentation of the margin just beneath it. Anterior margin projects beyond hinge about one-sixth, and posterior margin one-fourth of shell length. Greatest height about one-third distance from posterior margin, with the hinge, the longitudinal axis of the shell, and the ventral margin diverging posteriorly. Hinge surface is shown to be non-denticulate by one mold developed by acid treatment. The right valve is believed to lap strongly upon the left valve along the ventral margin, although the overlap data furnished by the studied material are not fully satisfactory.

Valve wall thick. Surface rather strongly convex, with greatest convexity somewhat anterior to midlength; in an uncrushed external mold the convexity is somewhat more than one-fourth of length. An obscure border extends along each terminal margin, but disappears ventrally in the region of overlap for a distance of about one-half to two-thirds the shell length. Antero-dorsal or eye tubercle lies one-third distance from anterior edge and one-sixth distance below dorsal margin; the tubercle is weak externally, but tends to be more strongly reflected on the internal mold due to indentation of inner surface of the valve. Below tubercle on inner surface of valve is a widely flaring, chevron-shaped ridge, the apex downward; the ridge has obscure, vertically directed, weak furrows and ridges on its dorsal slope; the ridge leaves a well-marked groove on the internal mold, but is imperceptible on the external mold. Post-ventral to the chevron-mark is a well developed, oval muscle scar, its diameter about one-seventh to one-eighth of the shell length. The muscle scar is represented on internal molds by numerous, closely spaced more or less rounded depressions representing elevations on the inner valve-surface; the subscars are larger near the middle of the scar area, smaller near the periphery. Because of the variable size, and especially because of complex subdivision of the marginal subscars, it is difficult to obtain satisfactory counts of the subscars. The subscars number around 130 to 150 in the holotype internal mold.

Fine ornament is apparently lacking on the exterior of the valve.

The holotype valve measures length 7.7 mm., height 5.3 mm. The largest observed example is 9 mm. long.

Relationships.—Chevronalis has the chevron mark observed in numerous Silurian and Devonian Leperditiinae; but has a non-denticulate hinge like that of the Middle Ordovician *Eoleperditia fabulites*, whereas the hinge is denticulate where known in Silurian and Devonian species of the subfamily. This combination of characters suggest that *chevronalis* may be Late Ordovician or Early Silurian in age. *Chevronalis* provides the most suggestive information now available for judging the age of the pre-Cretaceous shales in which it has been found.

Occurrence.—Core No. 4, at 6965 to 6985 feet, Warren Chandler No. 1 well, Early County, Georgia.

Subfamily ISOCHILININAE Swartz, n. subf.

Leperditiidae in which the valves develop flattened borders along the ventral as well as the terminal margins, and in which the closed shell appears essentially equivalved, though one valve may have a marginal flange overlapped by the other.

Relationships.—There is a good deal of reason to believe that the differentiation of the Leperditiidae into inequivalved forms without ventral border, and into seemingly equivalved types with complete marginal borders, exemplified early in Ordovician time by *Eoleperditia* on the one hand and *Isochilina* on the other, represents the development of racial stocks that maintained these essential differences into the Devonian period. The proposed classification recognizes this plausible view of the leperditiid-isochilinid history.

Occurrence.—Ordovician to Devonian in North America, Greenland, Eurasia; Devonian of Spitzbergen.

Genus ISOCHILINA Jones 1858

The genus *Isochilina* was originally described by Jones (1858) in the following words:

> Equivalved, the margins of the valves meeting uniformly, not overlapping as in *Leperditia*. Greatest convexity of the valves either central or towards the anterior portion. Eye tubercle present. Muscular spot not distinct externally.

As originally figured, the type of the genus, *Isochilina ottawa* Jones (1858), has a dorsally truncated, subelliptical to subovate outline; the surface of the valve is broadly convex, with a flattened border extending from cardinal angle to cardinal angle; other ornament is not shown save for the distinctly elevated eye tubercle.

In the course of the present study, problems arose as to the nature of *Isochilina* and especially as to the character of the muscle-scar details. Specimens that appear to represent *Isochilina ottawa* have very kindly been furnished by G. Winston Sinclair and by Cecil Kindle. The collections donated by Sinclair include material from L'Orignal, Ontario, one of Jones' original localities for *I. ottawa;* even if identity with *ottawa* in the strictest sense is not yet fully established, it does seem clear that the figured examples truly portray the generic features of *Isochilina.*

Proceeding on this assumption, it is suggested that the generic features of *Isochilina* are to be sought in the following characters:

Isochilininae with valves approximately equal; a flattened border extends along the free margins of each valve; eye tubercle is well defined, situated in antero-dorsal (dorso-antiplenate) part of each valve, and is represented on inside of valve by a distinct pit. Other ornament typically subdued, though a shallow depression may occur dorsal to the adductor scar, and some low, inconspicuous nodes may be developed near the hinge; in one new species, here described, there are externally elevated venose lines.

In the genotype, at least, the right but not the left valve has small pits along the flat border, that reflect small nodes of the inner surface. These nodes plausibly functioned in the contact relations of the valves, and it is likely that the edge of the left valve made contact with the right between the nodes and the outer edge of the border. Presence of these nodes is tentatively considered a generic character for *Isochilina.*

Genotype.—*Isochilina ottawa* Jones.

Relationships.—The foregoing analysis of *Isochilina* will, if accepted, require removal from the genus of various unbordered species that have been attributed to it. Emphasis on the submarginal inner nodes of the right valve should further restrict the stratigraphic range of the genus, though information about the nodes is generally not available in published figures and descriptions. The pits figured by Jones (1858, 1891) on the borders of *Isochilina gracilis* and *Isochilina ottawa* var. *intermedia* presumably represent nodes of this type, though no statement is made about inner nodes or about restriction to one as compared to both of the valves.

The internal, right-valve nodes of *Isochilina ottawa* recall the nodes of the corresponding valve in *Eoleperditia fabulites,* though the latter are stronger and differently placed. In both forms, it is plausible that the nodes are part of the contact apparatus of the shell. In both instances, the nodes

represent an early feature, that disappears in post-Ordovician derivatives.

Subocular muscle spots are more strongly developed in *Isochilina ottawa* than in *Eoleperditia fabulites*, but as in that species they had not attained the well-defined chevron arrangement found in such forms as the Silurian isochilininid, *Dihogmochilina straitcreekensis*, or in various Silurian and Devonian leperditiinids. The occurrence of a strongly marked, internal chevron ridge in *straitcreekensis* as in the Silurian and Devonian species of *Leperditia* and *Herrmannina*, appears at the present time to be an interesting example of parallel development in related but diverging stocks.

The genus *Hogmochilina* has been proposed by Solle (1935) for isochilinids with a shallow, subvertical sulcus posterior to the eye tubercle. A very weak furrow occurs dorsal to the adductor scar in *Isochilina ottawa* and is more strongly developed in *I. ottawa* var. *intermedia* Jones. It does not seem to the writer that *Hogmochilina* can properly be distinguished from *Isochilina* solely on the basis of a dorso-submedian furrow; it does appear, however, that in Solle's material the furrow tends to occur between the eye tubercle and the adductor scar, rather than in alignment with the adductor scar; further, there is no evidence that members of *Hogmochilina* have the submarginal, inner, right valve nodes that occur in *Isochilina ottawa*. Pending further information, it seems desirable to the writer to place emphasis on the position of the furrow and absence of the submarginal, inner, right valve nodes in continuing the use of *Hogmochilina*.

The genus *Dihogmochilina* Teichert likewise lacks the right valve nodes of *Isochilina ottawa;* its relationships are considered more fully on other pages.

Occurrence.—*Isochilina* as here understood is probably restricted to Ordovician strata.

ISOCHILINA OTTAWA (Jones)
Plate 67, figures 1–15

Leperditia (*Isochilina*) *ottawa* JONES, Ann. Mag. Nat. Hist., ser. 3, vol. 1 (1858), p. 248, pl. 10, fig. 1.—JONES, Geol. Surv. Canada, Org. Rem., Decade III (1858), p. 97, pl. 11, fig. 14.
Isochilina ottawa JONES, Monthly Micr. Jour., Mem. 4 (1870), p. 191.—JONES, Ann. Mag. Nat. Hist., ser. 5, vol. 14 (1884) p. 345.

Shell longitudinally subovate in outline, truncated dorsally by the straight hinge which is about seven-tenths of greatest length. Cardinal angles well defined, tending to be accentuated by subjacent emarginations; posterior angle more obtuse than the other. Posterior or plenate margin more broadly and regularly rounded than the anterior, and projecting about twice as far beyond limits of the hinge. Ventral margin convex, fuller posteriorly than anteriorly, most extended slightly behind midlength where height of valve equals about two-thirds of its length.

Hinge simple, the contact margins not appreciably thickened or otherwise modified, so far as observed. Valves are essentially equal, without appreciable overlap; the right valve has, however, a series of 16 to 18 small nodes on the inner surface close to the ventral and anteroventral margins of the valve; these are lacking in the left valve, and it is plausible that the contact margins of the left valve fit against the right valve between the nodes and the edge of that valve. The nodes continue about one-third the distance up the anterior margin of the right valve, but do not reach the posterior margin. They are reflected externally by small, shallow pits, situated along the marginal border.

Convexity of valve about one-fourth of length, reaching its maximum about one-third distance from anterior end and slightly below midheight. Surface drops to all margins with a convex curvature, except for the slight concavity that defines the inner side of the marginal border; the border is not truly flat but maintains a moderate slope toward the edge of the valve. A narrower, more obscure border is set off along the posterior half of the hinge by a weak groove.

Eye tubercle is small, low, persistently present, represented on valve interior by a distinct pit; it lies slightly less than one-fourth distance from anterior margin, about one-eighth distance below dorsal margin. Behind the eye tubercle, the surface of the valve is slightly depressed, forming a short, shallow, undefined, subvertical furrow. Postdorsal to the depression and slightly in front of midlength of hinge is a small node or swelling.

In line with the depression posterior to the eye tubercle, and about one-third the dis-

tance below the dorsal margin, the adductor scar may be reflected by a faint depression or, in some valves, an obscure swelling.

On well-preserved valves, there are very minute, relatively distant puncta.

On the inner surface of the valve, the adductor scar tends to form a shallow depression of oval outline, its leperditiid detail obscure in most of the studied examples. Weak, narrow venose markings radiate from the adductor. Below the pit corresponding to the eye tubercle are seven or eight obscure scars, that are closely adjacent to one another, and subvertically elongated. These subocular marks are weak and do not form a ridge on the inner surface; they are scarcely if at all reflected externally. The material studied is not sufficiently translucent to permit observation of the detail of either these or other muscle scars by wetting of the external surface.

A large left valve measures length 6.5 mm., height 4 mm., convexity about 1.7 mm.

Relationships.—Isochilina intermedia (*ottawa* var. *intermedia*) Jones (1891), of Chazyan beds near Aylmer and elsewhere in the Province of Quebec, is a close relative of *ottawa* in which the shell is not so oblong, the posterodorsal angle less prominent, the anteroventral margin less fully curved, and the post-ocular depression stronger. The eye tubercle as illustrated by Jones is broad and relatively anterior in location. There are pits on the border of the right valve that evidently reflect internal nodes.

The Chazyan as well as the Beekmantown (?) material illustrated in the present paper is closer to *ottawa* than to *intermedia*, judging from comparisons with Jones' illustrations.

Occurrence.—Isochilina ottawa was originally described by Jones on the basis of specimens from the "Calciferous sandrock" or presumed Beekmantown near Grenville, Quebec, and from Chazyan beds at nearby L'Orignal, Ontario. The Grenville examples should probably be regarded as the types. The material here figured was supplied as follows. From G. W. Sinclair: (a) slabs from near L'Orignal, Ontario, the horizon according to Sinclair's notes having been classed by Raymond as Chazyan in 1903, as Beekmantown in 1913; (b) slabs from the Pamelia limestone, 1 mile north of Aylmer. From Cecil Kindle: (c) slabs obtained about 10 miles west of Ottawa, Ontario, and a quarter-mile south of the Ottawa River, in presumed Chazyan beds.

Isochilina venosculptilis
Swartz, n. sp.
Plate 66, figure 13

Shell subovoid in outline, truncated dorsally by straight hinge which extends about four-fifths of greatest length. Cardinal angles obtuse but well defined, with slight subjacent emarginations. Posterior margin extends beyond hinge about one-eighth of length of shell; just below midheight it curves more rapidly than in its upper and lower parts. Anterior margin somewhat recessive in lower part, its curvature being most rapid about one-third distance below dorsal margin. Ventral margin broadly convex, fullest submedially where height of shell is about three-fifths of length.

Surface of valve moderately convex, the maximum convexity somewhat in front of and slightly below the valve center. A flattened border of moderate width extends along the free margins from cardinal angle to cardinal angle. Eye tubercle low, situated about one-seventh distance below dorsal margin, nearly one-third distance from anterior terminus. Posterior to eye tubercle is a shallow sulcus, extending from dorsal margin to slightly below level of the tubercle. In line with this sulcus, and about three-tenths distance below dorsal margin, is an external reflection of a round adductor scar, and from this there radiate appreciably elevated, flexuose, irregularly forking venose lines, that extend to the inner edge of the marginal border.

The holotype and only known specimen is a left valve that measures length 5.5 mm., height 3.5 mm.

Relationships.—The externally elevated venose lines of *venosculptilis*, and the external reflection of the adductor scar, represent a trend away from the smooth surfaced condition of *Isochilina ottawa*, and suggest an approach toward the more strongly sculptured *Dihogmochilina* and *Saffordellina*. It will likely prove, however, that *venosculptilis* has the type of valve contact found in the associated *ottawa*, with the right valve border-pits and corresponding internal nodes. Unfortunately, the species is as yet known only from a single left valve.

Occurrence.—Very rare, Pamelia limestone, 1 mile north of Aylmer, Quebec, in material donated by G. Winston Sinclair.

Genus HOGMOCHILINA Solle, 1935

The genus *Hogmochilina* was proposed by Solle (1935) as a subgenus of *Isochilina* with the following diagnosis:

Isochilina-Arten mit ± senkrecht zum schlossrand verlaufander, breiter Furche in der vorderen Schalenhälfte seltener in der Mitte, auch vor dem Augenhöcker kann eine kurze Furche vorhanden sein. Augenhöcker meist vorhanden. Rand saum haufig. Schale glatt oder punktiert.

Genotype.—*Isochilina* (*Hogmochilina*) *elliptica* Solle.

Relationships.—As stated by Solle, the basis for erection of *Hogmochilina* was found in the presence of the furrow that occurs behind the eye tubercle and is essentially perpendicular to the hinge.

The reinvestigation of *Isochilina ottawa* (Jones, 1858) immediately makes it clear that presence of a postocular, vertical furrow is not sufficient for even subgeneric separation of *Hogmochilina* from *Isochilina*. *Isochilina ottawa* itself tends to have a subvertical furrow, albeit a weak one, and in *I. intermedia* Jones (1891) the postocular depression is strong. *Intermedia* has the right valve submarginal pits and nodes of *ottawa*, and was originally regarded by Jones as a variety of that form; the writer too believes that *intermedia* must be retained in *Isochilina* as a very close relative of *ottawa*.

Despite the presence of a furrow in *ottawa* and *intermedia*, it appears that *Hogmochilina* can be distinguished because of the position of its furrow between the eye tubercle and the adductor scar, rather than in line above the adductor as in *ottawa*. Judging from Solle's figures, too, the members of *Hogmochilina* lack the right valve submarginal pits and corresponding internal nodes that occur in *Isochilina ottawa* and *I. intermedia*.

Information is still needed to show whether the members of *Hogmochilina* have a marginal, inner flange in the left valve, overlapped by the right valve, when the shell is closed, in the manner found in *Teichochilina jonesi*.

Occurrence.—Devonian of Spitzbergen.

Genus TEICHOCHILINA Swartz, n. g.

Isochilininae with marginal border well developed ventrally as well as terminally; the closed shell appears equivalved, but actually the left valve has a well developed marginal flange that is overlapped by the

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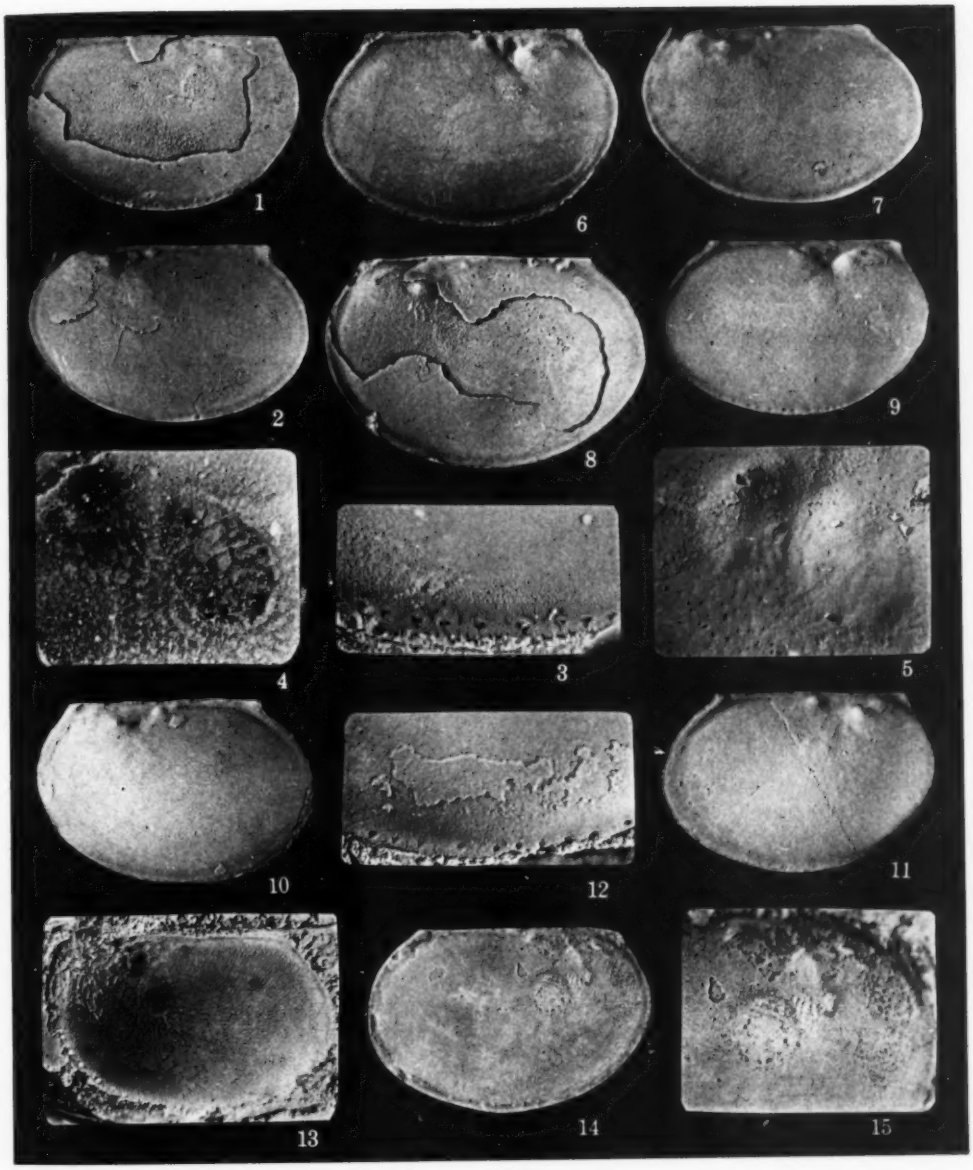
EXPLANATION OF PLATE 67

FIGS. *1–15*—*Isochilina ottawa* Jones. *1, 2*—Right and left valves, ×8 and ×6½, showing small variations in outline and, in *1*, the mold of the adductor scar. *3*—Part of the ventral border, ×20, of specimen illustrated in figure *1*, showing the small pits present on the right but not the left valve. *4*—Part of interior of a right valve, ×20, showing the eye-pit, the subocular muscle scars, the large, obliquely elongated adductor scar. *5*—Part of exterior of a valve, ×20, showing the eye tubercle, weak reflection of the subocular mark, an unusually elevated reflection of the adductor scar, and the minute, distant puncta. Beekmantown (?) beds, near L'Orignal, Ontario; gift of G. Winston Sinclair. *6–9*—A right valve, ×5½, two left valves and a right valve, ×8, showing some variations in outline, and in strength of the postocular depression or furrow and its adjacent node. The differences in apparent strength of the furrow are in part a result of the lighting. The furrow may, however, prove of sufficient value to allow differentiation of the specimens of figures *6* and *9*, and possibly *7*, from other specimens of this plate. In figure *8*, removal of part of the shell wall reveals impressions of the subocular muscle marks. In figure *9*, some of the pits of the ventral border are visible. Pamelia limestone, 1 mile north of Aylmer, Quebec. Gift of G. Winston Sinclair. *10, 11*—A left and a right valve, ×8. The small dorso-median node is visible in both. *12*—Part of ventral border of a right valve, ×20, showing some of the small pits. *13*—Interior of a right valve, ×8, adhering to matrix, and showing the eye-pit, the adductor scar, and anterior-ventrally some of the small nodes reflected externally by the pits of the flattened border. Nodes are present along part of the ventral margin, but are not visible in the photograph. Venose markings radiating from the adductor scar are present, but are relatively very fine, and too weak to be clearly apparent in the picture. *14, 15*—Internal mold of a right valve, ×8, and part of same, ×20, showing impressions of the eye pit, the subocular muscle marks, and the adductor scar. The adductor scar is round rather than obliquely ovoid as is true in figures *4* and *5*. The differences in outline of the adductor may again prove of value for specific differentiations; but note that in the L'Orignal material the adductor scar is round in figure *1*, though obliquely ovoid in figures *4* and *5*. Presumed Chazyan beds, a quarter mile north of Ottawa River, and about 10 miles west of Ottawa, Ontario. Gift of Cecil Kindle.

(p. 322)



Swartz, Structures of Leperditiidae

right valve. Right valve submarginal pits and corresponding inner nodes of *Isochilina* type are lacking. The surface bears an eye tubercle, and behind this there may be an inconspicuous depression; ornament is otherwise subdued.

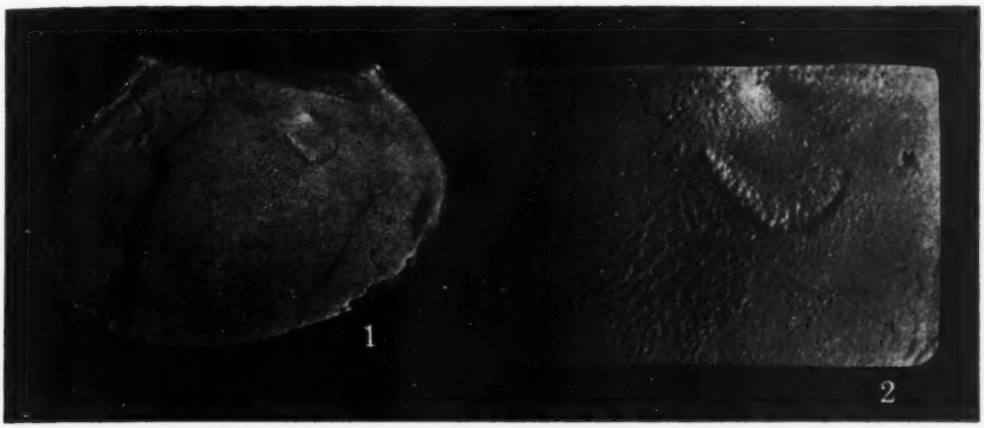
Genotype.—Isochilina jonesi Wetherby (1881), Ordovician, "Trenton" limestone, Kentucky. (For figures also see Ulrich and Bassler, 1923, Bassler and Kellett, 1934.)

Relationships.—Teichert (1937) in proposing the genus, *Anisochilina*, remarked that *Isochilina ottawa* lacks the internal sloping area of the left valve that was said, in Ulrich and Bassler's (1923) summary of Paleozoic ostracode genera, to be present in *Isochilina*. He concluded that *Isochilina* needs to be restricted so as to exclude species with such overlapped flanges, and proposed that they be included in *Anisochilina*.

Anisochilina, however, is based on *Anisochilina punctulifera* Teichert (1937), which does have an overlapped flange in the left valve, but which lacks any trace of marginal borders and is not, in the writer's opinion, an isochilininid but instead a leperditiinid. It may even be true that *Anisochilina punctulifera* will prove to have the features of *Eoleperditia*, or at least that it will prove to be very close to that genus, when the characters of the right valve are made known, and when the hinge and muscle scar structures are determined.

If the writer's understanding of *Anisochilina* is correct, that genus cannot fulfill the role envisioned by Teichert. Accordingly, the new genus, *Teichochilina*, is here proposed for isochilininids with complete marginal borders, having marginal structures of the type found in *Isochilina jonesi* and not those of *I. ottawa*.

Teichochilina will have to be restricted to forms lacking the distinct dorso-submedian furrow that occurs in *Hogmochilina* between the eye tubercle and the adductor location; but information about the contact relations in *Hogmochilina* is needed for fuller comparison of the two groups.



FIGS. *1, 2—Chevroleperditia chevronalis* Swartz, n. sp. *1*, internal mold of the holotype right valve, ×7. *2*, portion of the same enlarged ×20 to show the muscle scar impressions and chevron mark.

Some question remains as to whether *Teichochilina* deserves full generic separation from *Dihogmochilina*. As presently understood, *Dihogmochilina* includes strongly sculptured forms, *Teichochilina* weakly ornamented species in which the left valve tends to have a strong ventral flange overlapped by the right valve. *Dihogmochilina straitcreekensis*, described on accompanying pages does not have a strong, overlapped flange.

Occurrence.—Teichochilina jonesi occurs in Ordovician "Trenton" beds of Kentucky. Further work will be required to determine the constituent species of the genus, and to establish stratigraphic and geologic ranges.

Genus DIHOGMOCHILINA Teichert, 1937

Dihogmochilina was described by Teichert (1937) as follows:

This genus includes Leperditiidae that are similar to *Isochilina* but have a forked sulcus be-

hind the eye spot. The muscle spot is located between the forks of the sulcus.

Genotype.—Isochilina grandis var. *latimarginata* Jones (1891).

Relationships.—The diagnosis of *Dihogmochilina* proposed by Teichert needs some modification in recognition of characters displayed by *Dihogmochilina straitcreekensis* Swartz n. sp. *Straitcreekensis* is a flat-bordered isochilinid which in its strong sculpturing approaches *latimarginata;* there is a furrow above the adductor scar, but this opens into a shallow depression occupying the locus of the scar, and does not have forks enclosing the scar.

Since *straitcreekensis* appears clearly to belong in *Dihogmochilina* with *latimarginata* the following description is suggested for the genus.

Isochilininae with well-developed borders along the free margins of the valve; surface strongly sculptured, the adductor scar clearly reflected exteriorly; above the position of the adductor scar, the surface is creased by a shallow furrow. In *straitcreekensis*, at least, narrow flanges bend abruptly downward from the outer edge of the marginal border of both valves, the flanges probably overlapping when the valves were closed; submarginal right valve pits and corresponding internal nodes, such as occur in *Isochilina ottawa*, are absent here; there is a strongly developed chevron ridge below the eye tubercle.

Dihogmochilina differs from *Isochilina*, *Teichochilina*, and *Hogmochilina* in the stronger sculpturing of the surface. Its members lack the submarginal right valve pits and corresponding internal nodes that occur in *Isochilina ottawa*. In *Dihogmochilina straitcreekensis* there are narrow, presumably overlapping flanges, but the overlapped flange is markedly weaker than that of *Teichochilina jonesi;* the chevron mark found in *straitcreekensis* may likewise prove significant in distinguishing *Dihogmochilina* from *Teichochilina*. In *Dihogmochilina* the postocular furrow is dorsal to the position of the adductor scar; in *Hogmochilina*, the furrow lies between the eye tubercle and the position of the adductor scar.

An interesting feature of *Dihogmochilina straitcreekensis* is furnished by pits that occur dorsally and anterodorsally to the eye tubercle. It is reasonably clear that these were the loci of muscle attachments, comparable to the obscure spots found in corresponding positions in *Eoleperditia fabulites* and *Leperditia scalaris*.

Occurrence.—Silurian of the eastern United States, of western Manitoba and at northern end of Hudson Bay, Canada.

DIHOGMOCHILINA STRAITCREEKENSIS
Swartz, n. sp.
Plate 66, figures 14–16

Shell large, dorsally truncate, subovate in outline. Hinge about five-sixths of greatest length. Anterior end narrowly rounded, much lower than posterior end, which is fullest below midheight. Narrow flanges bend abruptly downward in each valve from the outer edge of the flattened border of the free margins, and presumably overlapped one another when the shell was closed. though direction of overlap is not established

Surface of valve moderately convex. Flattened border, extending along free margins of each valve, is defined on inner side by a shallow groove. Eye tubercle prominent; below it, a chevron groove makes a strong furrow on the valve surface. Postventral to eye tubercle and chevron groove, the locus of the adductor scar is depressed within a surrounding, low rounded ridge, which opens dorsally to a furrow perpendicular to the hinge margin. Elevated venose lines, strongest proximally, radiate from the outer margin of the ridge surrounding the adductor. Above and anterior to the eye tubercle are four small depressions.

The holotype valve measures length 8.5 mm., height 5.6 mm.; an exceptionally large individual would if restored measure about 14 mm. in length.

Relationships.—Dihogmochilina straitcreekensis is illustrated here in order to help the redefinition of the genus, to provide comparisons with the new figures of *Isochilina ottawa* and especially *I. venosculptilis*, and to illustrate the chevron groove and the pits anterodorsal to the eye, that are of interest in connection with accompanying sketches of the musculature of *Eoleperditia fabulites*, *Leperditia scalaris*, and *Herrmannina welleri*.

Occurrence.—Late Silurian Tonoloway limestone, near Monterey and Warm Springs Virginia.

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JOURNAL OF PALEONTOLOGY, VOL. 23, NO. 3, PP. 328–329, 2 TEXT FIGS., MAY 1949

PALEONTOLOGICAL NOTES

AN UNUSUAL SPECIMEN OF THE GENUS *ATHYRIS*

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The chert in the Burlington limestone of the Mississippi valley is well known for its fossil content, and for the preservation of the fine structural details of the contained fossils. A fragment of this chert recently found by Dr. M. G. Mehl near Columbia, Mo., has preserved in it an *Athyris* with the ornamentation and structure of the shell exceptionally well preserved.

The genus *Athyris*, as described by McCoy and later emended by Hall and Clarke (1895), is characterized by a fibrous lamellar shell. In certain species, such as *A. lamellosa* (L'Eveillé), the surface of the shell is ornamented by broad lamellar extensions which project outward from the shell for some distance, and appear as what might be called "frills." In some forms the frills appear to be present at each growth-line and the shell surface is smooth in the intervening areas. In other specimens these extensions seem to have several small low ridges between them. The lamellar extensions are thin and fragile and in most cases have been broken off before the shells were buried. Accordingly, most descriptions and illustrations of *Athyris* indicate a smooth or nearly smooth shell. Many descriptions mention "lamellar extensions" but few illustrations give any indication of their nature.

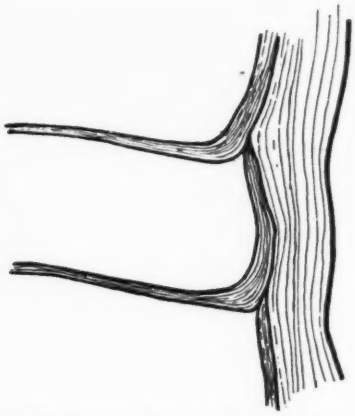

FIG. *1*—Diagrammatic sketch showing relationship of frills to rest of shell. Based on polished section near anterior margin of shell. ×20. (Bottom of illustration is anterior.)

In the specimen under consideration the original shell is present and thin lamellar extensions or frills have been very well preserved due to the specimen having been embedded in siliceous material before it was subjected to abrasion or crushing.

The preservation of the specimen is such that the structural relationships of the frills to the rest of the shell can be seen in section. They seem to be a specialized modification of the outermost fibrous layer of the lamellar shell. Each frill begins near the base of its posterior neighbor, lies along the shell surface for a short distance, then turns abruptly and extends outward nearly at right angles to the surface (Fig. *1*).

On one of the lateral zones of the dorsal valve five of the frills are present and are spaced at intervals of 1.5 to 5.6 mm. (Fig. *2*). They extend about 3 to 4 mm. from the surface and then curve smoothly toward the anterior part of the shell for a distance of as much as 3 mm. In at least two of them this forward trending portion is essentially at right angles to the proximal portion and is nearly parallel with the shell surface. At the base these frills are only about one-fifth the thickness of the shell and they thin gradually toward the outer edge, this outer edge becoming very thin and delicate. The frill which is near the mid-length of the valve thins very gradually and where it is exposed

in cross section appears almost as a fine hair. On the other lateral zone of the valve a portion of the anterior margin is preserved and here the frills are only about 1 mm. apart, but are of about the same width and thickness as the others.

In addition to the excellent preservation of the external ornamentation of the shell, this specimen also has a considerable portion of both spires preserved. They are present as calcareous coils of which the outer surface has been coated with a druse of fine quartz crystals. Except for the fine druse the shell is otherwise hollow and does not contain any chert. The lack of solid filling and the preservation of the delicate frills seems to indicate that this shell must have become embedded in a soft mass of siliceous material which hardened into chert.

The delicacy of the frills also raises an interesting question regarding the possible life environment in which such ornamentation could have developed.

The specimen under consideration came from a chert lens in the Burlington limestone in a quarry about 0.7 mile south of the city limits of Columbia, in the NW¼ sec. 19, T. 48 N., R. 12 W., Boone County, Missouri. University of Missouri, Specimen No. 8560.

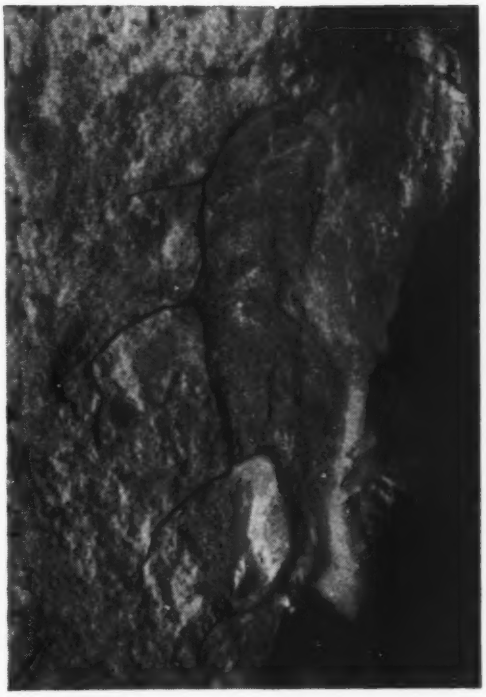

FIG. 2—Photograph of natural section through lateral zone of shell showing the frills in cross section. ×4.

CORRECTIONS OF FOSSIL LOCALITIES

TENG-CHIEN YEN

Mr. H. A. Tourtelot of the U. S. Geological Survey, has called attention to the following two errors on page 636 of my paper on "Eocene fresh-water mollusca from Wyoming" in JOURNAL OF PALEONTOLOGY, vol. 22, no. 5, pp. 634–640: (1) Locality B-5 for "Section 9," read "Section 29"; (2) Locality B-6 for "northwest of Lysite Mountain," read "southwest of Lysite Mountain."

JOURNAL OF PALEONTOLOGY, VOL. 23, NO. 3, P. 330, MAY 1949

NOMENCLATURAL NOTES

SCAPHITES MORROWI, NEW NAME FOR *SCAPHITES PYGMAEUS* MORROW 1935, NON HOLZAPFEL 1888

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Recently our attention was caught by the fact that the name *Scaphites pygmaeus* Morrow, 1935 (pp. 465–466, pl. 50, figs. 2–3) is preoccupied, This name was already used by Holzapfel (1888, p. 63, pl. 8, fig. 19) for a *Scaphites* from the Senonian sands of the Aachen region in western Germany. On the comparison of the figures concerned it becomes evident that the Senonian *Scaphites pygmaeus* Holzapfel, 1888, is specifically distinct from the Turonian (Carlile formation of Texas) *Scaphites pygmaeus* Morrow, 1935. Therefore, in accordance with the rules of International Zoological Nomenclature, it is necessary to rename the latter which is a homonym of *Scaphites* Holzapfel, 1888. We propose the name *Scaphites morrowi* (new name).

We would like to stress the circumstance that according to the recent conceptions of the taxonomy of *Scaphites* both forms above mentioned might easily be treated as representatives of different ammonoid genera or even families (comp. Nowak, 1911; Reeside, 1927, Roman, 1938 etc.). The form of Holzapfel (1888) should be referred to the genus *Discoscaphites* Meek, 1876 (= *Hoplo-scaphites* Nowak, 1911). That of Morrow (1935), on the contrary, should be referred to the genus *Scaphites* Parkinson, 1811 s. str. Yet this circumstance does not remove the necessity of replacing the name of Morrow (1935) since he did not accept the division of the genus *Scaphites* Parkinson, 1811 above mentioned in his paper. He refers to his form as *Scaphites pygameus* Morrow, n. sp. throughout the paper concerned. Holzapfel (1888) also, of course, uses the name *Scaphites pygmaeus* n. sp. throughout his paper. Therefore according to the International Zoological Nomenclature (comp. Edward J. Schenk and John H. McMasters, 1936, p. 37, Articles 35–36), the homonymy of the name of Morrow (1935) is an absolute one. Any later transfer of the forms concerned to different ammonoid genera or families does not allow use of the homonymous name of Morrow (1935) again.

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NOMINATIONS FOR MEMBERSHIP

Article 3, Chapter 1, of the By-Laws of the new Constitution and By-Laws adopted

by The Paleontological Society at the last Annual Meeting in New York City, makes the following provisions for the election of new Members to the Society:

"At each regular meeting of the Council, or at any meeting specifically called for this purpose, or by mail, the nominations [for membership] received by the Secretary shall be examined and, if approved, shall be forwarded to the Editor for early publication in the Journal of Paleontology.

"If, within sixty days following publication, no challenge to the applicant's eligibility has been received by the Secretary, it shall be deemed that the applicant is elected a Member, and he shall be so notified by the Secretary.

"But if, within this time, cause is indicated by any Member why the applicant should be rejected, the final declaration shall be withheld by the Secretary and the facts communicated to the other members of the Council, who, after due investigation, shall vote (either by mail or in person) whether to accept or reject the application. If the Council votes to accept the candidate in spite of such criticism, this shall constitute election, and the candidate shall be notified by the Secretary that he is a Member; but if the Council shall not so decide, then it shall be deemed that the applicant has failed of election."

In compliance with the above requirements, the Secretary herewith submits for consideration by the Membership of the Society the following names of applicants for election to Membership in the Society:

AFSHAR, FREYDOUN AZADI, 9654 Shahpour Ave., Teheran, Iran. B.S., 1936, Univ. of Idaho; M.S., 1946, Univ. of Chicago; during 1949 will be graduate student at The Johns Hopkins Univ. Geologist, Dept. of Mines, Iran. Interested in Invertebrate Paleontology, esp. Cenozoic Mollusca. Sponsored by H. E. Vokes and Thomas W. Amsden.

AYLOR, RICHARD BURNS, 601 Washington St., Jefferson City, Mo. A.B., 1946, A.M., 1947, Univ. of Missouri. Now geologist for Missouri Highway Commission. Interested in Invertebrate Paleontology and Stratigraphy. Sponsored by E. B. Branson and Raymond E. Peck.

GRYC, GEORGE, 3924 7th St., N.E., Washington, D. C. A. B., 1940, M.S., 1941, Univ. of Minnesota. Geologist, U. S. Geological Survey, and graduate student, The Johns Hopkins Univ. Interested in Stratigraphic Paleontology. Sponsored by W. A. Cobban and H. E. Vokes.

HAMILTON, EDWIN LEE, Bldg. 315, Apt. 14, Stanford Village, Stanford, Calif. B.S., 1936, Texas Agricultural and Mechanical College. Graduate student, Stanford Univ. Interested in Invertebrate Paleontology and Micropaleontology. Sponsored by Siemon W. Muller and A. Myra Keen.

HENBREE, MAX REED, 807 Rollins St., Columbia, Mo. A.B., 1948, Univ. of Missouri. Graduate student, Univ. of Missouri. Interested in Invertebrate Paleontology. Sponsored by Raymond E. Peck and A. G. Unklesbay.

HOSE, RICHARD KENNETH, Dept. of Geology, The Johns Hopkins Univ. B.S., 1943, Univ. of Alabama. Geologist, U. S. Geological Survey and graduate student, The Johns Hopkins Univ. Interested in Stratigraphic Paleontology. Sponsored by H. E. Vokes and Thomas W. Amsden.

JARVIS, DANIEL, Dept. of Geology, Stanford Univ., Calif. B.A., 1941, M.A., 1948, Texas Christian Univ., graduate student, Stanford Univ. (on leave from instructorship at T.C.U.). Interested in Stratigraphic Paleontology (esp. Permian). Sponsored by Siemon W. Muller and A. Myra Keen.

KOENIG, JOHN WALDO, State Geological Survey of Kansas. B.S., 1947, Columbia Univ. Geologist and scientific illustrator, State Geological Survey of Kansas, and graduate student, Univ. of Kansas. Interested in Invertebrate Paleontology (esp. bryozoa). Sponsored by S. K. Chakravorty, Alfred G. Fischer, and Cecil G. Lalicker.

MOORE, WAYNE ELDON, 745 Tower Road, Ithaca, New York. B.S., 1946, Univ. of Illinois, M.S. 1948, Cornell Univ. Graduate student and assistant, Cornell Univ. Interested in Micropaleontology. Sponsored by W. Storrs Cole and John W. Wells.

PIPIRINGOS, GEORGE NICHOLAS, Dept. of Geol., The Johns Hopkins Univ. A.B., 1947, M.A., 1948, Univ. of Wyoming. Geologist, U. S. Geological Survey, and graduate student, The Johns Hopkins Univ. Interested in Invertebrate Paleontology. Sponsored by H. E. Vokes and Donald A. Myers.

SNYDER, CHARLES THEODORE, P.O. Box 383, Billings, Montana. B.S., 1948, Univ. of Arizona. Geologist, U. S. Geological Survey. Interested in Stratigraphic Paleontology. Sponsored by Edwin D. McKee and Alexander Stoyanow.

ROBERTS, HENRY BARNDT, Wagner Free Inst. Science, 17th St. and Montgomery Ave., Philadelphia 21, Pa. Curator of Museum, Wagner Free Inst. Science. Interested in Invertebrate Paleontology. Sponsored by Horace G. Richards and B. F. Howell.

STEWART, ROBERT HARRY, U. S. Geological Survey, Box 1390, Plant City, Fla. A.B., 1943, Miami Univ., Ohio; M.S., 1946, Northwestern Univ. Geologist, U. S. Geological Survey. Interested in Micropaleontology. Sponsored by W. P. Woodring, F. Stearns MacNeil, and J. Brookes Knight.

VERASTEGUI M., PEDRO P., Dept. of Geology,

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WHITEMAN, ARTHUR JOHN, Dept. of Geology Stanford Univ., Calif. B.Sc., 1948, Univ. of London, Eng., Eric Knight Jordan Fellow, Stanford Univ., Calif. Interested in Invertebrate Paleontology, esp. upper Paleozoic. Sponsored by A. Myra Keen and Siemon W. Muller.

WINTERS, STEPHEN S., 825 South 10th St., Newark 8, N. J. A.B., 1942, Newark Univ.; A.M., 1948, Columbia Univ. Instructor in Geology, The Newark Colleges of Rutgers Univ. Interested in Invertebrate Paleontology. Sponsored by Norman D. Newell and Marshall Kay.

NOTICES

THE CENTER OF PALEONTOLOGICAL STUDIES AND DOCUMENTATION OF THE PARIS MUSEUM (C.E.P.D.)

This Center, which has been in operation for the past two years in the Laboratory of Paleontology of the Paris Museum of Natural History, at 3 Place Valhubert, is a useful office of documentation. It is equipped to furnish, by means of microfilms, photostat copies, or letters, information, and bibliographic and systematic references in the following fields:

1. General information about the Earth Sciences, such as the location of important collections, the meaning of geological and stratigraphic terms, the location of specimens needed for comparison, etc.

2. Information about mineralogy, petrography, structural geology, geophysics, applied geology, regional geology, stratigraphy, paleontology, and biology.

3. References to descriptions of, and copies of figures of, all kinds of animals and plants (bibliographies, lists of species, genera, or groups of higher rank, and systematic classifications).

The paleontological collections of the Center are available for examination. Casts of important specimens can be supplied.

The information that has been assembled in the Center has been gathered from the systematic abstracting of 2500 periodicals. Very complete compendia are made of various subjects according to the demand or need for them. The paleontologic bibliography and documentation can be developed according to the requirements of those who desire to use them.

The center can furnish resumes of papers, translations (including translations of Russian and Polish papers) and photographs of type specimens in old collections (of the kind prepared by Palaeontologia Universalis). Publication was begun in November, 1948, of a quarterly bulletin containing news about the work of the Center and the information that it can supply.

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The Geology Department of the School of Mines and Metallurgy of the University of Missouri, Rolla, Missouri, announces the availability of fellowships and assistantships for the study of paleontology, particularly micro-paleontology, for the academic year 1949–50.

Inquiries should be addressed either to the Chairman of the Geology Department or to the Chairman of the Committee on Graduate Study.

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